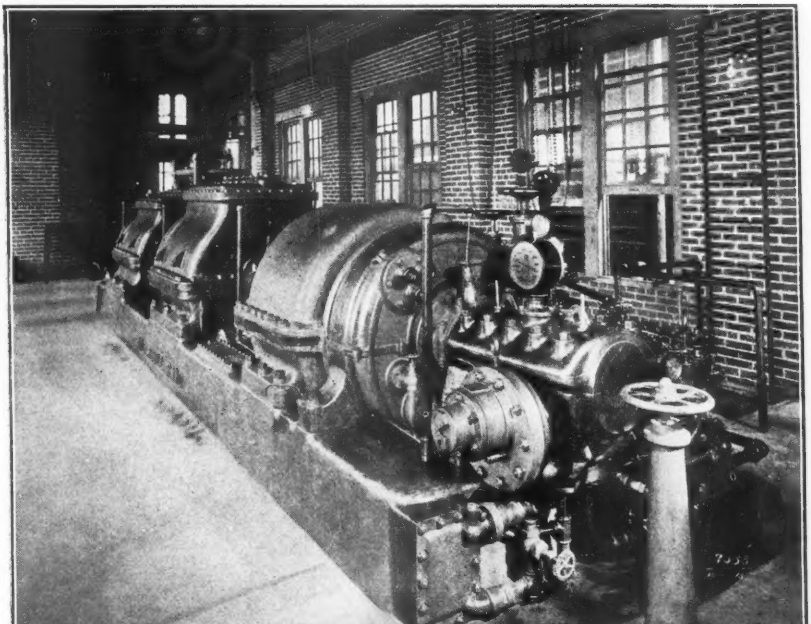
COMPRESSED AIR MAGAZINE

DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. xx SEPTEMBER 1915. No. 9

A Type of Air Compressor That Is Being Increasingly Used in Compressed Air Production.



A Turbo Compressor installed in the Power House of the Terminal Railway Station, St, Louis, Mo. Capacity, 3,500 cu. ft. per min. at a pressure of 100 lbs per sq. in. This unit is driven by a mixed pressure steam turbine at 6,000 R. P. M.

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Published by THE COMPRESSED AIR MAGAZINE CO., Easton, Pa.
NEW YORK, Bowling Green Building LONDON, 165 Queen Victoria Street

Classified Buyers' Guide, Pages 14 and 16. Index to Advertisers, Page 8.

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COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

Vol. xx SEPTEMBER, 1915 No. 9

TO GET DRY COMPRESSED AIR

BY FRANK RICHARDS.

In a recent interesting account of the compressed air installation for driving a tunnel, are mentioned two compressors, each with a rated capacity of 427 cu. ft. of free air per minute. Air was conducted to two receivers in the compressor house, one being 3 ft. in diameter by 8ft. 3 in. long, and the other 3 ft. 6 in. by 8 ft., then into the mine through a 4-in. pipe 3725 ft. long, more than ⅔ of a mile, to a receiver 3 ft. 6 in. by 8 ft., thence 350 ft. through a 3-in. pipe line to the starting point of the tunnels, and through 3-in. branch lines to within 50 ft. of the faces.

It was stated that the compressors were placed outside the mine "mainly to insure getting dry air, as the atmosphere inside the mine contains a large amount of moisture due to the sprinkling to lay the dust and the natural wet condition of parts of the mine. By having the compressors outside the mine, no trouble whatever was experienced from the freezing of the air drills."

The statement relating to the compressed air supply, and the complete avoidance of the freezing-up trouble, seems to call for some comment, since, as it stands, it embodies a prevalent misunderstanding as to the conditions to be observed in successful compressed air practice.

Those who have had much to do with the use of compressed air for driving rock drills, pumps, etc., are sufficiently familiar with the annoying presence of water in the air, and of the trouble it is apt to cause by freezing up and choking the exhaust passages. This was certainly not lost sight of in the description above referred to, since we are told in it that the compressors were located outside the mine "mainly to insure getting dry air," and also that "by having the compressor thus outside the mine, no trouble was experienced by the freezing at the air drill."

Of course, the story as told is true enough, and I have not the slightest doubt as to the facts or experiences narrated; it is only the deductions or explanations given about which there can be any question. Locating the compressor outside the mine for the purpose of getting dry air, and then the happy experience with the drills when there was no free moisture to freeze, and therefore no freezing up, had not the slightest relation to each other as cause and effect.

A little reflection must suggest at once that hundreds of compressors have been thus located outside mines and tunnels, where all of them could have been expected to get dry air just as surely as in this case; and yet it has been the rule rather than the exception that the drills or other tools driven by the air from these compressors have had a persistent habit of freezing up, not alone on account of the low temperatures of the exhaust, but also, and principally, because water was present in sufficient quantity to accumulate in the form of ice in the exhaust passages. Evidently something more is needed than the location of the compressor in this case to account for the immunity, and it is not difficult to find a sufficient explanation.

NO AIR IS DRY.

There is no such thing as dry atmospheric or "free" air. Whenever air is spoken of as "dry" it is only that it is drier than some other air. And how could it be otherwise, when one of the most important and perpetual func-

tions of the air is the conveyance and distribution of water over the earth? Air is always drier in some places and wetter in some places than in others. Here are a few local mean percentages of atmospheric humidity from tables of the U. S. Weather Bureau: Galveston, 85; New York City, 73; Walla Walla, Wash., 65; Rapid City, S. Dak., 60; Salt Lake City, 53; Yuma, Ariz., 42; El Paso, 39. It is somewhat curious that the places of the highest and lowest humidity in the United States are thus both in Texas.

Moisture which is thus intermixed with the air is in the form of perfectly transparent and invisible vapor, until a humidity of 100 per cent, or the point of saturation, the dew point, is reached, which may be said always to occur in the compression and transmission of air at the ordinary working pressures, say 6 atmospheres or 75 lb. gage, and immediately that this point is passed, the excess of moisture condenses into actual water, but still mixed with the air, the super-saturated air then appearing as fog or mist. The freed water which forms the cloud will slowly settle out of the air if it is quiet long enough. If air in this condition is passing through a pipe, the water will wet the interior and trickle down to the bottom, where in time it will form a flowing stream and be carried along with the air current.

THE UNSTABLE DEW POINT.

The saturation point of air constantly varies, and is determined by its pressure and its temperature, especially the latter. At a fixed temperature any given volume of air is saturated when it contains a certain quantity of water vapor, and this almost regardless of the pressure, which affects the capacity of air for water vapor only by changing the volume. If the absolute pressure of a certain quantity of air is, say, doubled, by which the volume is reduced one-half, the moisture capacity is reduced in the same proportion, so that, if the humidity of the free air is 50 per cent, this humidity becomes 100 per cent when the air is compressed to 2 atmospheres, or 15 lb. gage, and if it is compressed to 6 atmospheres, 90 lb. absolute, or 75 lb. gage, a very common working pressure, the humidity becomes 300 per cent, and 200 per cent of this the air will refuse to carry as vapor.

That is, it would so refuse to carry this excess of moisture if its temperature remained constant, which thus far we have assumed to be the case, but that is far from the fact. As air is compressed its temperature rises rapidly, and with each rise of about 20 deg. its capacity for moisture is doubled. Starting with free air at 60 deg. F., if it is compressed to 75 lb. gage, its temperature at delivery, no matter how perfectly the cylinder may be water-jacked, will be above 300 deg., so that in consequence of this change of temperature, the capacity of the air for moisture will have been doubled so many times that when it leaves the cylinder the relative humidity will be quite low, although it still carries all the moisture with which it started. It might be called exceedingly dry air, and with the receiver placed near the compressor, as it generally is, its temperature in passing through the receiver will still be too high for it to get to a condition beyond saturation and release the water; and, as a matter of fact, under the conditions here suggested, little water is ever drawn from air receivers so located.

It is to be borne in mind that the conditions under which compressed air will have the lowest capacity for moisture are high pressure and low temperature. As the air leaves the compressor, and before it begins to be used, it is of course at its highest pressure, and in its flow through the pipes its temperature is reduced, so that when it arrives at the point where its work is to be done it should be at a low temperature and carry a minimum of moisture, if the opportunity has been provided for getting rid of the moisture as it condenses.

In the case under consideration, the air was conveyed through the pipe line more than 2/3 of a mile, and we may be sure that it was thoroughly cooled by the time it got to the end. Long before it got there, the saturation point was reached, and the water began to wet the pipe and to flow along the bottom as previously mentioned. This water would finally be carried into the receiver which, fortunately was provided at the far end of the pipe, and other moisture would separate from it while passing through the receiver, this water being drawn off from time to time. It was the presence of this receiver which prevented the drills from freezing up, by intercepting the moisture before it could get to the drills, not the locating of the compressor outside the

tunnel, which really had nothing to do with it. A receiver or some means of catching the water after the air has made its run through the pipes is necessary, but it is not easy to see the use of the receivers near the compressor, if the line pipes are of reasonable size.

When 2-stage compressors are employed for ordinary working pressures, as is always to be recommended and is now quite customary, a little of the water may be intercepted in the intercooler, and much of it would be liberated by an aftercooler; but a receiver or a water separator at the end of the run is generally necessary to complete the work. More or less water is sure to be in the air in excess of its capacity, and its presence will assert itself if it is not disposed of.—*Practical Engineer.*

THE AUTOMOBILE TORPEDO

In the world-war which still rages with unchecked momentum the supreme terror is the submarine, and the submarine is nothing except for its torpedo. To our readers especially any information concerning the latter must make a strong appeal since compressed air, as will appear, is its breath of life.

The automobile torpedo is not a novelty. It was invented fifty years ago by an engineer of the Austrian navy named Lappis, who made his first torpedo in a shop at Fiume, a seaport on the Adriatic, owned by Robert Whitehead, an Englishman. The first torpedoes were called Luppis-Whitehead, but the first part of the name soon dropped off and the Whitehead torpedo has been known all over the world ever since.

Soon after our civil war some twenty different nations bought the rights to use the torpedo and many of them have continued to develop it, the changes and additions not always coming to the knowledge of the public.

An elaborate description of the up-to-date torpedo has recently appeared in *Le Genie Civil*, of Paris, an abstract of this appearing later in *The Engineer*, London, whose cuts are here reproduced with necessarily an additional abridgement of the text.

The earliest torpedoes were 14 in. in diameter, 14 ft. 6 in. long, weighing 600 lbs. and carrying a charge of 40 lb. of gun cotton, with a range of 450 yards and a speed of 20 knots. The torpedo of to-day has a minimum diameter of 17.7 in., a length of 20.5 ft. and a weight of 1540 lb. It carries 220 lb. of gun cotton and has a range of 1100 yds. at 43 knots, or 8700 yds., at 28 knots, according to its type. Speed and long range cannot be combined in the same torpedo. Some of the navies have torpedoes much larger in all their dimensions.

The Whitehead torpedo as it is now made consists of: (1) The striker and detonator; (2) the explosive chamber; (3) the compressed air reservoir; (4) the machinery chamber; (5) the aft flotation chamber; and (6) the tail portion which carries the propellors and rudders, see Fig. 1.

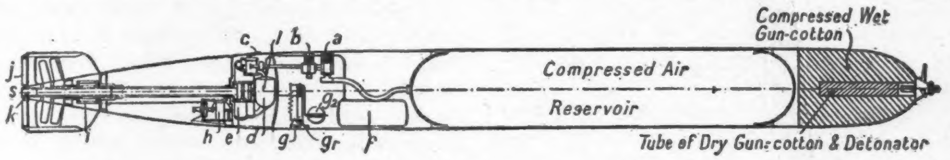


FIG. I. SECTION OF WHITEHEAD TORPEDO.

The charge of explosive is contained in a metal envelope which can readily be detached from the rest of the torpedo, and which is called by the French the *cone decharge.* The explosive employed in the French navy is wet gun cotton, compressed into annular cakes, which are piled one on top of the other. In its wet state the gun cotton does not take fire if brought into contact with a flame, and is not detonated even by very powerful shocks. It can even be cut with a saw or drill if care be taken to avoid local heating. The amount of water used by the French for dampening is as much as 25 per cent of the weight of the gun cotton. The wet cotton is exploded by a small charge of dry gun cotton, which is itself exploded by a fulminating mercury detonator. The dry cotton is carried in a water tight cylinder, and it is put in its position at the head of the torpedo just before firing. The detonator is at the front end of the cylinder, and it is exploded by a striker when the torpedo comes in contact with an obstacle.

The striking head of the torpedo is shown in

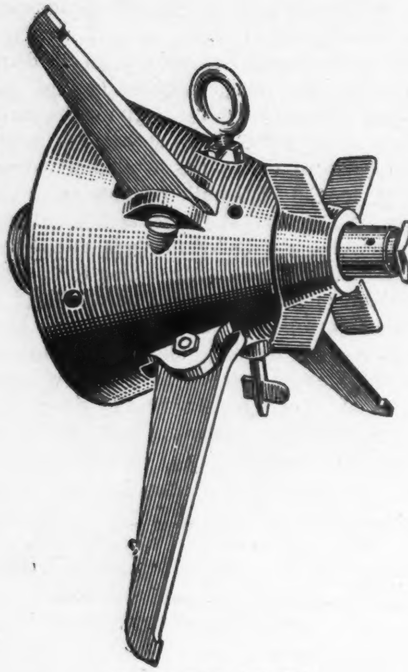


FIG. 2. THE STRIKER.

Fig. 2. The striker is, before the torpedo is fired, held out of action by a small propeller arranged in front of the striking head and screwed to it. As soon as the torpedo is traveling through the water, the propeller revolves and travels along the threads of the screw until it has reached a position which disengages the striker so that the latter is free to move and to explode the detonator, which it does at the moment of striking the object aimed at, whether by contact with the striker itself or with either of the three projecting levers.

Whitehead first tried the propelling of his torpedoes by the wind and then he used coiled up springs but finally adopted compressed air which has been used ever since. The pressure at first was about 1,200 lb. per sq. in., but to increase the speed the pressure was increased and as high as 2100 lb. was employed.

REHEATING THE AIR.

It was found, however, that so much cold was produced by the sudden expansion of the air at this pressure that ice appeared in such quantities that the operation of the machinery was interfered with. To counteract this it was determined to reheat the air inside the torpedo. The first device having this object was the apparatus of the Bliss torpedo. In this the combustible liquid was set fire to at the moment the torpedo was discharged. At the present time gasolene or alcohol is employed. It is contained in a separate reservoir and it is burnt in a special appliance called the reheater. M. Gesztesy also had the idea of injecting water in a fine spray into the heater. This water on being vaporized prevents an excessive increase of temperature and also increases the volume of the products of combustion all available for motor driving.

The Gesztesy system is shown diagrammatically in Fig. 3. The inflammable liquid, gasolene or alcohol, heats not only the compressed air but also the injected water which is thus vaporized and mingled with the air. In Fig. 3, A is the compressed air reservoir. From it a pipe k leads to cock C, from which another pipe k^1 leads to a pressure regulator D, which in its turn is connected by a pipe k^2 to a "retarder" I. From the latter the air passes to the combustion chamber or reheater E. Beneath the latter is a combustible reservoir F, from which a pipe a leads up to E.

The retarder I, shown in section in Fig. 4, has for its object the gradual setting in operation of the main engines, and the regulation of the supply gasolene and water to the reheater, as well as the firing of the combustible mixture. By this it is possible when firing a torpedo from an above water tube to delay the starting of the motor machinery until the torpedo is actually in the water.

The retarder consists, Fig. 4, of a cylinder provided with two pistons, N and N^1, both keyed to the same spindle. When the cock C, Fig. 3, is closed, so that no air is passing, the two pistons occupy the position shown; that is to say, they are pushed as high up as they will go in the cylinder under the action of spring O, and the piston N covers the discharge port D, Fig. 4, while the piston N^1 presses upward against the stop P. When the air is admitted through pipe A the pistons can only descend slowly, for first of all the resistance of the spring O has to be overcome, and then the oil which fills the cylinder underneath N^1 has to be forced through the hole Q as the piston descends; hence several seconds must elapse before port D is fully open.

Part of the Combustion chamber E, Fig. 3, is provided with double walls. There is first of all an outer case b which is seated on the

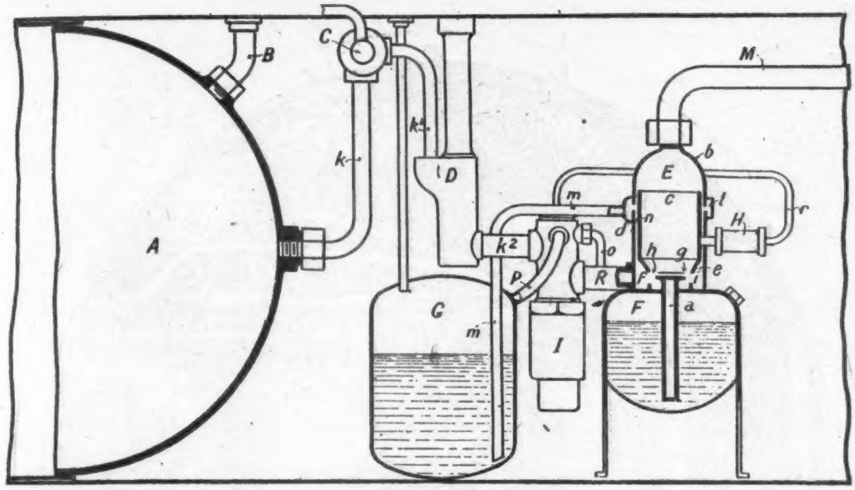


FIG. 3. GESZTESY REHEATER.

gasolene reservoir. Inside this there is a cylinder *c*, the bottom of which, having the form of a truncated cone, is furnished with an annular plate. It is this cylinder which is the combustion chamber properly so-called. Between the case *b* and the cylinder *c* there is an annular space *e*. The pipe *a* which comes upward from the reservoir is furnished with a cylindrical portion *g* which has transverse channels *h*. This portion *g* divides the lower part of the space *c* into two parts, of which the lower is in communication with the space *e* by means of the holes *i*. The air arriving from the reservoir A enters the annular space *e* through the pipe R. Around the cover or case *b* is a circular channel *l*, to which is attached the water pipe *m* and which communicates with the annular space *d* by means of small holes. A tube *o* joins the retarder I with the benzine reservoir and a tube *p* joins the retarder to the water reservoir G, so that the air pressure will tend to force the water up through the pipe *m*.

The lighting arrangement H is put in operation by the compressed air, which reaches it through the pipe R. As soon as the torpedo motor is started an inflammable substance, which burns slowly and remains lighted for about seven seconds, catches fire and the flames are led into the combustion chamber.

The working of the reheater may be explained as follows. As soon as the torpedo is fired the cock C, Fig. 3, opens and the air flows to the regulator, which reduces the pressure to that required for use. The air then flows through the retarder into the combustion chamber, in which it mingles in the annular space *d* with the combustible liquid coming up the pipe *a* from the reservoir F, and with water coming from the reservoir G. The air entering the space *e* is divided into two portions. One of these, entering through the holes *i* in the lower part of the combustion chamber, passes between *f* and *g* and lifts and pulverizes the benzine flowing from the orifice in the siphon *a* and pushes the vapor thus formed up to the level of H, where it inflames. The other portion of this air flows across the space *d*, in which it pulverizes the water which arrives by the pipe *m* and causes it to mingle with the products of combustion arriving from lower down in the apparatus. The air, the products of combustion and the water vapor then pass away together to the engine through the pipe M. The temperature in the combustion chamber rises to about 250 deg. Cent., and this is also the

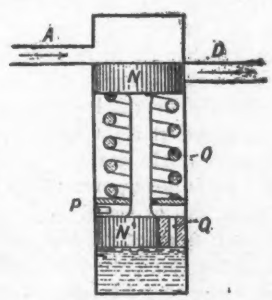


FIG. 4. RETARDER.

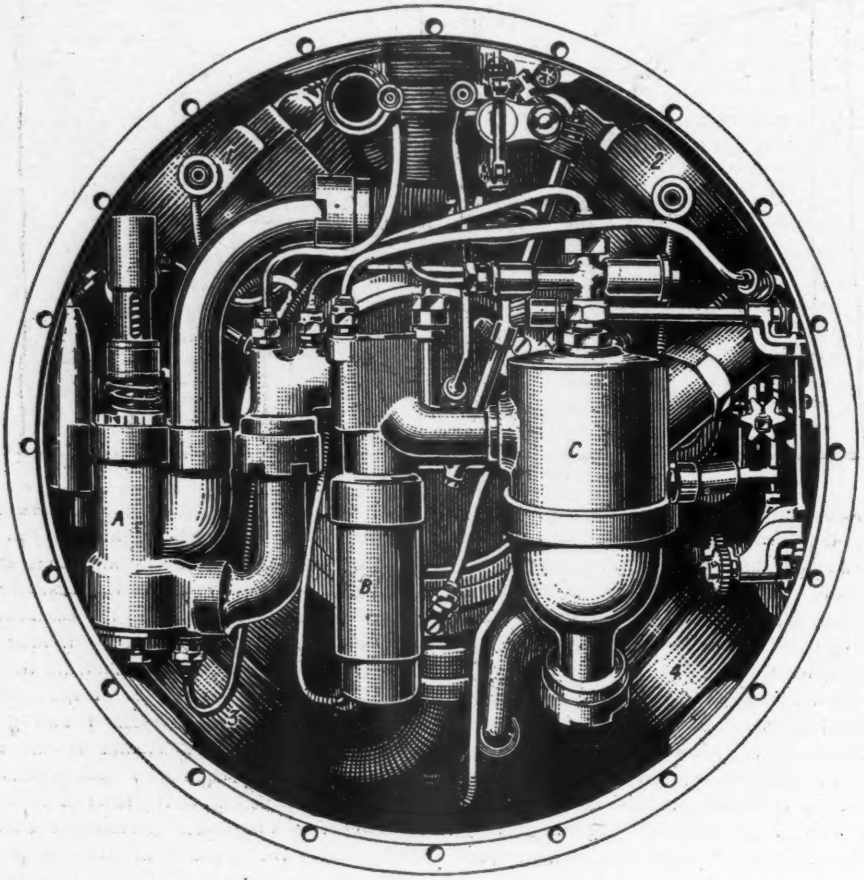


FIG. 5. SECTION THROUGH ENGINE COMPARTMENT.

temperature of the combined mixture, which is high enough to annul the freezing effect brought about by the expansion of the gases as they are exhausted from the engine. Moreover, the energy contained in these gases is greatly in excess of that in the air alone, and this fact has resulted in a considerable increase in the radius of action of torpedoes without an increase of their dimensions.

The motor which propels the torpedo is of the four cylinder Brotherhood type, with the cylinders arranged at right angles and all operating upon a single crank. It is designed to develop 120 horsepower with an air pressure of 570 lb. and at speed of 1200 revs. per min. The shaft is made hollow so as to allow the escape of the gases after doing their work, the exhaust being thus liberated at the rear of the propellers. There are two propellers, one rigidly secured to the main shaft and the other to a hollow shaft or sleeve. These shafts by the aid of gearing revolve in opposite directions, this being done to avoid irregularities in the travel of the torpedo and also to counteract the tendency to roll the torpedo over. A section of a Whitehead torpedo, taken through the engine compartment, is shown in Fig. 5. In this the four cylinders of the motor are designated by the numbers 1, 2, 3, and 4; the pressure reducer by A, the retarder by B, and the reheater by C.

Elaborate devices are employed for steering the torpedo and especially for controlling its striking depth. In these details there have been various developments, some of them more or less secret, so that no complete description can be attempted.

The arrangements for securing that the tor-

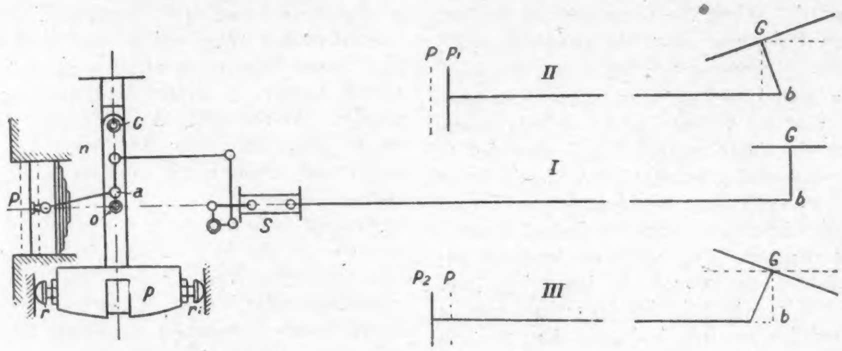


FIG. 6. DIAGRAM OF DEPTH CONTROLLING APPARATUS.

pedo shall strike the object at the desired depth are shown diagrammatically in Fig. 6. In this P is a piston, one side of which is open to the water in which the torpedo is immersed the other side being engaged by a spring, the pressure of which can be varied to suit different depths of submersion. The stroke of this piston is only a few milli-meters. A pendulum *p* is hung on knife edges at *c*, and its oscillations are limited to 3 or 4 degrees by means of spring buffers *r* r^1 pressing against stops. The movements of the piston P are transmitted by a connecting-rod to a point *a* on a lever which is pivoted at *o* to the pendulum *p*. The other end of the lever is connected to a relay or servo-motor S, which is worked by compressed air and which controls the position of a plate G which forms a horizontal rudder. The exact position of this rudder varies in different types of torpedo. In Fig. 7 it is in front at both sides of the propellers, as shown at *a*. In some cases, as is in fact seen in Fig. 1, the rudder is behind the propellers. If these plates be horizontal, as in diagram I, Fig. 6, the torpedo will travel horizontally. This will be the condition when the pressures on both sides of the piston P are equal. Should, however, the torpedo have a tendency to dive or to go into deeper water, the pressure on the water side of P would become greater than that due to the spring, and the consequence would be that the plate G would be brought to the angle shown in diagram II, Fig. 6. This would of course tend to make the torpedo rise to the surface. On the other hand, should the torpedo tend to rise to the surface the water pressure on P would be overcome by the spring and the plate G would be brought to the position shown in diagram III, and the torpedo would then be directed

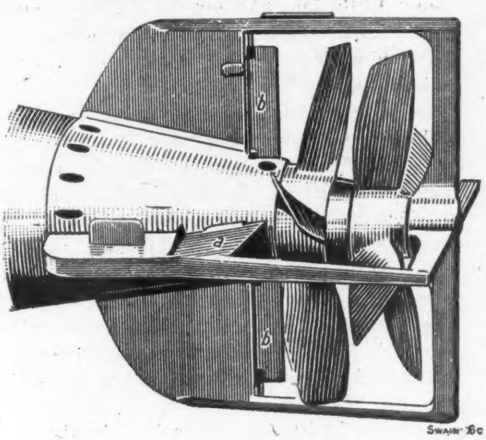


FIG. 7. RUDDER AND PROPELLERS.

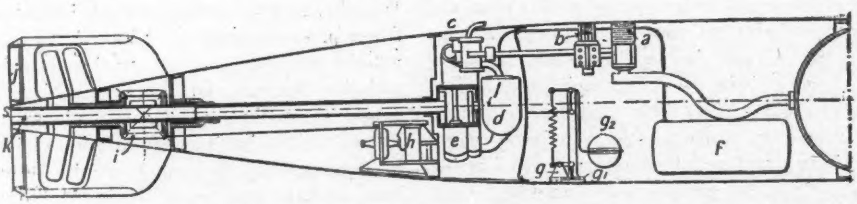


FIG. 8. SECTION SHOWING VARIOUS PARTS.

downward. When the pressures on the two sides of P become equal the rudder G again becomes horizontal.

As a matter of fact, what happens in practice is that the torpedo, which is very rarely fired at the depth at which it is intended to strike, eventually reaches that depth by a series of oscillations, the amplitude of which gradually decreases until the desired immersion is attained. The ordinary depth of immersion for the attack of battleships and cruisers is nearly 10ft. but torpedoes can be regulated for much less depths than this, so that the Germans have been able to use them with success against small merchant vessels and trawlers only drawing perhaps between 5ft. and 6ft. of water.

For controlling the direction of the torpedo vertical rudders—see *b b*, Fig. 7—are employed. These are controlled by means of a gyroscope. If the tendency of the torpedo is to deviate to one side or the other of the line in which it is aimed the gyroscope automatically brings it back again. Here, too, there are in practice oscillations of decreasing amplitude before an undeviating line is reached, since the torpedo, having deviated, is brought back over the centre line before it can be stopped. The relative positions of the hydro-pendulum and the gyroscope are shown in Fig. 8.

ROCK-DRILL NICKNAMES

Rock drills, like human beings, acquire nicknames. Some were derived from those of the pioneer drill manufacturers, others were originally trade names of the drills and gradually became accepted as representing that entire type of drill. In other cases the names are descriptive of the action of the machines. The pioneer in the rock-drill field was the Burleigh drill, introduced in the Hoosac Tunnel in 1866 by the Burleigh Rock Drill Co., of Fitchburg, Mass. This was one of the first large engineering undertakings in this country, the object being to tunnel the Green Mountains, the natural barrier to traffic between New York and the New England States. The Burleigh rock drills, later used in the Western mines in considerable numbers, were quite heavy and required two men to handle them. When the smaller, one-man drills were introduced, the runners still continued to call all heavy, two-man drills "burleighs," irrespective of make. Opposed to the "burleigh" is the "chippy," the name given to all piston machines lighter in weight and running more rapidly. As the demand on one-man drills in recent years has been for more and more speed and strength, the machines have increased in weight to such an extent that the application is now hard to see. The "Waugh" was one of the first stoping drills to appear. In some of the Western camps the miners still commonly refer to any stoper as a "waugh." Down South a stoper is commonly known as a "warrior," a peculiar development from the original name, explainable only by the colloquial peculiarity. For a similar reason, or lack of reason, the hollow-steel hand-hammer drill is commonly called a "murphy." The name "jap" is also sometimes applied to this type of drill, and is derived from the trade name "Little Jap." Among the highly coloured names sometimes heard among the miners for the stoping drill are the "wiggle-tail" and the "window-maker." The "wiggle-tail" is very descriptive of the operation of the machine, and the "window-maker" refers to the unhealthy effect the dust has on the miners' lungs. Fortunately, the introduction of sprayers, bags and atomizers for laying or catching the dust at the mouth of the hole, and the enforcement of the use of them by some State laws, are a start in the right direction toward making the last-mentioned name inapplicable. When the first self-rotating hammer drill was introduced several years ago, it was given the name of "Jackhammer" by the manufacturer. This name had taken such a hold by the time competitive self-rotating hammer drills appeared that it was found quite difficult to apply any other name which would be accepted and adopted by the drill men. With the one-man piston drills and the use of hammer drills for drifting, it appears only a question of time until the "burleigh," or heavy two-man piston drill, will be used very little underground. When the self-rotating stoper becomes fully developed and generally adopted, no more use will be had for the tail or the "wiggle-tail," and this creature will die a natural death. It would seem that, with the tendency toward lighter-weight hammer drills and self-rotation in stoping drills, the miner of the future will have an easy time of it.—J. R. McFarland, in the *Engineering Journal*.

POINTS ABOUT AIR-COMPRESSOR PRACTICE

BY R. H. ROWLAND.

The installation of a compressed-air plant calls for a large initial investment, but once established, it is not expensive to maintain. The first cost should not be considered too much, the work to be done should be well considered, and a plant established of sufficient size, not only to supply the present requirements, but to have ample margin to permit an increase of from 25 to 50 per cent. in air consumption. The installation should be first-class in every item, and in order to minimize the losses, only good workmanship and sound material should be used.

In order to properly determine, say for mine traction, the size of motor and the tank capacity, it is in most cases necessary to work out in foot-pounds the energy for doing this work. The factors entering into this calculation are: (1) Weights of the empty and loaded cars; (2) frictional resistance, which is dependent on the condition of road and rolling stock; (3) grade resistance, which is the severest condition of grade; (4) curve resistance, depending on the sharpness and length of the curves; and (5) the daily output and most desirable size of train. Having determined these conditions, the size of the motor and storage tanks required can be readily determined.

LAWS GOVERNING COMPRESSION.

To intending users of compressed air a knowledge of the laws governing the changes in the temperature, pressure and volume of air should be of value. They are as follows: Let

P, V *and* T = The initial pressure, volume and absolute temperature, respectively, of a given weight of air,

and

p, v and t = The final pressure, volume, and absolute temperature, respectively, of a given weight of air,

then

At constant temperature, $PV = pv$ (a)

At constant pressure, $\frac{V}{v} = \frac{T}{t}$ (b)

At constant volume, $\frac{P}{p} = \frac{T}{t}$ (c)

The following formulas apply if air be compressed or expanded adiabatically:

$$\frac{p}{P} = \left(\frac{V}{v}\right)^{1.408} \qquad (d)$$

$$\frac{t}{T} = \left(\frac{V}{v}\right)^{0.408} = \left(\frac{p}{P}\right)^{0.29} \qquad (e)$$

The units of work U required to compress a volume of air V to a volume of air v, or to compress a volume of air V from P to p, are:

1. Adiabatically, that is, without loss of the heat due to compression:

$$U = \frac{PV^{1.408}}{0.408}\left(\frac{1}{v^{0.408}} - \frac{1}{V^{0.408}}\right) \qquad (f)$$

2. Isothermally, that is, at constant temperature,

$$U = P\,V\ hyp.\ log \frac{V}{v} \qquad (g)$$

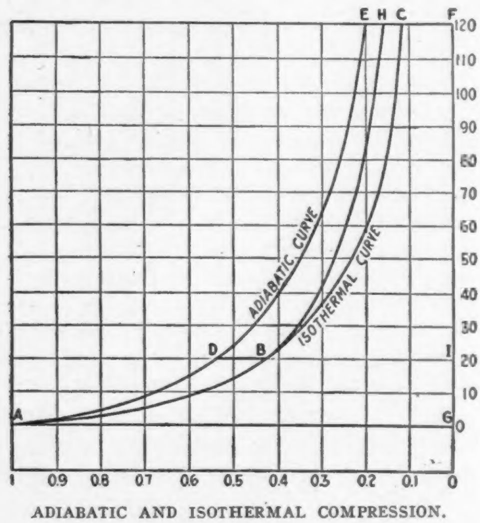
When air is compressed adiabatically, the rise in its temperature is an exact measure of the work done upon it; and therefore the units of work required to compress it can be calculated from the increase in temperature. The rise in temperature $t - T$ is given by (e), and the units of work equal this quantity multiplied by the weight of air in pounds by the specific heat of air at constant volume expressed in foot-pounds, namely, 130.2. Thus if W = weight of the air in pounds,

$$U = (t - T)\ W\ 130.2 \qquad (h)$$

It is generally known that when air is expanded it becomes cooler, that its pressure, if confined, is increased when heated, and that it is cooled when the pressure is reduced; also, that the compression of air (or any gas or steam) is accompanied by a rise in temperature, but specific information regarding the resulting loss of power and the extent to which this heating effect can be neutralized by proper construction and design is not always accessible. There are two limiting conditions under which the compression of air may be accomplished.

Assume that a compressor compresses air at about atmospheric pressure and at 63 deg. F. into one-third of its former volume. It is known that at a constant temperature its pressure would then be 45 lb. absolute and

(45 — 15) 30 lb. above the atmospheric pressure. Inasmuch, however, as the temperature is not constant and rises, the compression into one-third volume will in this case actually raise the air temperature from 63 deg. F. to 360. This temperature should therefore give a pressure of about 55 lb. above atmospheric pressure instead of 30 lb., and if the air could be kept at this high temperature, it would remain at this pressure and the result would be perfect, inasmuch as when the air was used in the cylinder it would expand from 55 lb. above atmosphere to the atmospheric pressure, and at the same time would cool from 360 deg. F. to 63. If the heat of compression is removed as fast as generated and the compression proceeds under a uniform temperature, it is said to be isothermal, and the compression curve follows the line *ABC* in the diagram.



ADIABATIC AND ISOTHERMAL COMPRESSION.

If this could be accomplished, the air, when used, would give back practically the same amount of work as had been performed upon it in compressing, and if practicable, the heat absorbed from the air by the cooling agent could be applied to the air during its reëxpansion in use along a similar isothermal curve, the result being perfect thermodynamic efficiency. It is toward an approximate realization of these ideal conditions that compressor practice is directed, but in service the compressed air has to be taken a long way in pipes, and since these pipes radiate the heat, the air is correspondingly cooled; and if it should be cooled down to its original temperature (63 deg. F.) while still occupying the same volume, its pressure will have fallen to 30 lb. above atmosphere; and this is what does occur.

In the diagram the line *ADE* represents adiabatic compression, during which no heat is removed from the air and in consequence of which the temperature rises. The result of this rise in temperature is plain; since a given weight of air at a given pressure occupies a volume proportional to its absolute temperature, the volumes at all pressures are greater in adiabatic than in isothermal compression, in a ratio increasing with the pressure; and since the work of compression and discharge is represented by the area in the diagram to the right of the curve along which compression is accomplished, it will be seen that the area *ADECB* stands for the waste of energy caused by allowing the heat of compression to remain in the air.

The efficiency is the percentage which the power given out by the motor bears to the power required to compress the air in the compressor, and the ultimate power developed at the motor is often a small percentage of the power expended. In many cases losses are due to poor design and faulty installation, and the efficiency often may be as low as 30 per cent.; which would perhaps appear misleading and unfavorable if the manner in which the power is used were not considered.

LOSSES IN COMPRESSION.

In adopting recent designs, with all the latest improvements, the cubic feet of air compressed per hour per horsepower has been considerably increased. The power can be transmitted, say at a pressure of 60 lb., two miles distant with an efficiency of about 60 per cent. on the indicated horsepower of the compressor engine, and without reheating. By heating the air this efficiency can be raised to about 80 per cent.

The primary causes of loss are: First, generation of heat during compression, which passes away by radiation without producing useful effect; this loss of heat representing an equivalent loss of work. Secondly, during compression, the temperature of the air being increased, its bulk is increased. Also, during compression from atmospheric pressure to 45 lb. above, its bulk is increased so

much by the increase in temperature that what should be two becomes three cubic feet in the air cylinder; whereas on leaving it, with reduction again of the temperature, the bulk is again reduced to two cubic feet, so that the compression is performed on a larger bulk of air than that which work is obtained from. This is the most important point. Thirdly, inability to get full expansion out of the compressed air at the motor. The air on arriving at the motor is at or near the temperature of the atmosphere and always holds some moisture in suspension. On expanding in the cylinder of the motor, its temperature will fall so much that the moisture will freeze and ice will form in the exhaust passage of the engine.

Other causes of loss, or secondary causes, are: Resistance to air passing through suction and delivery valves, clearance losses in cylinder, leakage past the piston, losses from friction of mechanism, losses in air mains from leakages, and from friction in air mains of too small diameter.

There have been several methods adopted for diminishing the loss of power in compressing air, and the primary losses described above have to some extent been obviated by surrounding the compressor cylinders with cold water, or water-jacketing, so that the surface of the cylinder shall not be heated during compression. This reduces the volume of the air, and consequently less work has to be done upon it to compress it, and therefore less heat is generated in compression. By this means the temperature is not raised high, and therefore less heat, that is, less work, is lost by radiation during the operation. It is also necessary to cool the cylinders for other reasons, such as lubrication and the packing of the piston rod and valves. Also, when the cylinder is very hot, the air that enters from the atmosphere is at once heated and expanded, before the inlet valve has closed; and thus the air compressed by each stroke will fill a smaller volume when it has cooled in the receiver and pipes. This smaller volume at equal temperature and pressure represents a proportionately smaller quantity of work.

MULTI-STAGE COMPRESSION.

Another method is to adopt stage compression with intermediate cooling, which means discharging the air from the cylinder after partial compression has been effected, completely removing the heat generated during the first compression and then compressing to final pressure in another cylinder. This method is called two-stage compression, and when repeated one or more times for high pressures, multi-stage compression.

In two-stage and multi-stage compression the air may be compressed to 35 lb. in the low-pressure cylinder, then passed through the intermediate cooler to the high-pressure cylinder for further compression. For pressures of four atmospheres and upward, the extra first cost, etc., of a stage compressor will pay for itself in a short time, because the loss which arises from heating of the air increases rapidly as the pressure increases. Stage compression reduces these losses.

Cylinder jackets are indispensable in keeping the cylinder walls sufficiently cool for effective lubrication and in the prevention of cumulative heating. At ordinary speeds the indicator diagrams from an air cylinder show a compression line approaching the adiabatic curve much more closely than the isothermal. Diagrams having compression lines deviating considerably from the adiabatic are naturally regarded with suspicion, and leaks through the valves or past the piston may be considered probable.

The chief advantages of multi-stage over single-stage compression are:

1. Lower average temperature, resulting in lower average pressure and permitting the compression of the same volume of air with less expenditure of energy.

2. Increased safety and ease of lubrication. When high final temperatures prevail, part of the lubricating oil vaporizes, and wear on the piston and cylinder becomes rapid. Under exceptional circumstances the combination of air and oil vapor may reach the proportions of an explosive mixture, and if the compression temperature passes its flash point, damage may result. Such accidents are rare even in single-stage work; in multi-stage compression, with proper intercooling, they are improbable, if not impossible.

3. Greater effective capacity in free air. The final pressure in the low-pressure cylinder is much lower than in the single-stage machine, and the air confined in the clearance spaces when expanded to atmosphere occupies comparatively little space. Consequently, the in-

flow of air through the suction valves begins at an earlier point in the stroke.

Referring again to the diagram and assuming the compression in each cylinder to be adiabatic, the compression curve is represented by the interrupted line *ADBH;* the compression proceedingly adiabetically in the first cylinder to *D;* the air then being withdrawn and cooled in a suitable vessel, usually called an intercooler, until its initial temperature is reached and its volume reduced from *ID* to *IB;* with good intercooler arrangements it may be further reduced, being then introduced into a second cylinder and compressed adiabatically, as before, along the line *BH.* The energy required to compress and discharge a given quantity of air under isothermal conditions (perfect efficiency) is proportional to the area indicated by *ABCFG.* The waste energy in two-stage compression (proper conditions, of course, being assumed) is proportional to the two smaller areas *ADB* and *BHC;* while the loss of energy in adiabatic (approximately single-stage) compression is represented by the whole area *ADECB.* The saving effected by constructing the air end for two stages is, therefore, represented by the portion *DEHB.*

PREVENTING ICE FORMATION AT EXHAUST.

As it is uneconomical to use air without expansion, some means must be adopted to use it expansively without being encumbered with the freezing difficulty. Several methods have been devised for heating the air before it reaches the motor, so as to obtain the necessary expansion and avoid the freezing. When compressed air is used to drive an engine, the air has already cooled down nearly to its former temperature. When it is expanded in the cylinder down to atmospheric pressure, its temperature falls very low, and thus its pressure on the piston falls much more rapidly than it would if the temperature remained constant. When the air is exhausted its temperature is usually much below the freezing temperature of water, and therefore, the moisture in the air is frozen on the exhaust valves and causes much trouble by choking them with ice. In the writer's opinion, the best means to adopt to diminish the loss from this cause would be to provide air receivers of a large size, both near the compressor on the surface and near the engines underground, where the air is used; these, together with air mains of ample dimensions, would give sufficient time to deposit moisture, and with large and straight exhaust passages no trouble need be experienced from ice, because if there is no water or moisture, there can be no ice.

In dealing with the secondary losses that may occur by the suction valves not being large enough or the springs upon them being too strong (the negative suction pressure sometimes amounting to 2 or 3 lb. per sq.in. —a serious loss of power), valves actuated mechanically are to be preferred, but these are more suitable for large-sized compressors, and are often found to be too great a refinement for small ones.

ATTENTION TO DELIVERY VALVES

Delivery valves should be properly adjusted, capacious, easy and quick in action. They should open immediately the piston pressure equals the receiver pressure and should close again immediately it becomes less. The compressor cylinder should be frequently indicated to see that the valves are in proper working order.

Clearance losses also are troublesome. The piston should, of course, work as close as possible to the cover, so as to reduce the clearance space to a minimum. Only the best kind of piston rings should be used in the air cylinders. The piston of an air compressor is more difficult to keep tight than a steam piston; the moisture from the steam helps to keep the piston ring tight, but the reverse happens with dry air.

LOSSES DUE TO MECHANICAL FRICTION

The losses from friction of mechanism depend chiefly on the accuracy of workmanship, the arrangement of the compressor and the efficiency of lubrication; all of which should be well attended to in the design and future working of the compressor. Equally so, good and reliable workmanship will often result in diminishing the losses from leakage in the air mains. In poor arrangements great loss will result from leakages at the joints of the air pipes, and more care is necessary with these than with steam pipes, because a leakage of steam can easily be seen, whereas small leakages of air cannot. Good joints should be made at first, providing properly for con-

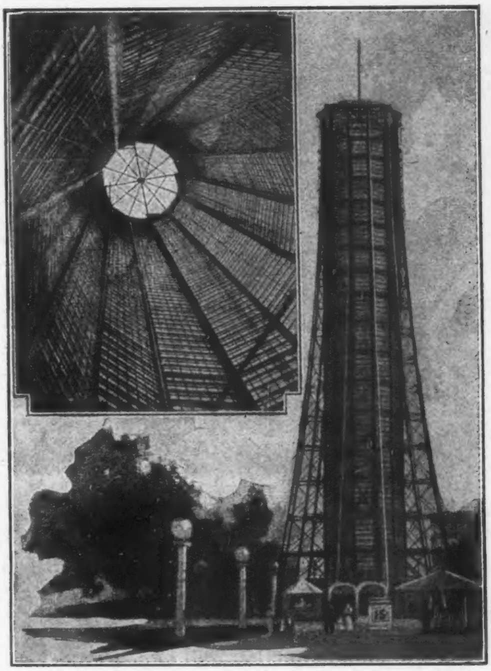
traction and expansion, and they will give little trouble afterward. The air mains should be sufficiently large. The loss due to friction in air mains increases, not directly as the velocity, but as the square of the velocity. Should the air mains be too small, it is evident that the air will be wire-drawn, the pressure will be diminished, and the greatly increased velocity will produce increased friction. The delivery in the pipes should be more than equal to the quantity that the engines worked are capable of taking out.

WHEN TO USE SINGLE—AND WHEN TO USE MULTI-STAGE COMPRESSORS.

The decision of air-power users in regard to the method of compression must be the result of compromise between considerations of first cost and running cost. Below 60 lb. terminal pressure the adiabatic loss is comparatively trivial, and within this limit and at low altitudes single-stage compression is to be recommended. Between 60 and 100 lb. the amount of fuel is usually the determining factor in a choice, though high altitude may also enter the question. Above 100 lb. both safety and economy speak for two-stage, and above 500 lb., multi-stage compressors.

With increase in altitude, the atmospheric pressure decreases from 15 lb. per sq.in. at sea level to about 10 lb. at 10,000 ft. above sea level. Since the density of the air decreases with its pressure, it is obvious that at such altitude the total weight of air handled by a given displacement is considerably less than at sea level and that to fill any volume with air compressed to 90 lb., a greater free-air displacement will be necessary than would be required at sea level. As the heat generated during compression is dependent upon the number of compressions, and since this number when compressing, for instance to 80 lb., is considerably increased at higher altitudes, it naturally follows that two-stage compression is more imperatively needed at high altitudes than it is at sea level.—*Power*, somewhat abridged.

A PNEUMATIC OBSERVATION TOWER



PNEUMATIC OBSERVATION TOWER.

The half-tone here reproduced from *Popular Mechanics* shows the essential features of a novel observation tower for popular amusement which has been built at or near one of the parks of Chicago. It may be described as a glass cylinder or tube 200 feet high and 30 feet in diameter traversed by a piston which is driven up the tube by compressed air carrying within or upon it a load of passengers up to 125 at a time. The tube is not strictly cylindrical, having 12 flat sides which are composed of more than 1,000 window sashes with over 15,000 panes of plate glass. There is of course a heavy and elaborate steel framework amply strong and staged to resist all possible stresses, with a liberal factor of safety. The glass lining is said to be capable of resisting an internal pressure of 10 lbs. to the square inch, while to raise the full load of passengers to the top only ¼ lb. per square inch is required. There are rods over the top to prevent the carriage from being driven up out of the tube and besides this precaution there are posts provided near the top of the tower which will permit the surplus of air to escape when the carriage reaches the top. About two and a half minutes are used for the ascent and the descent is completed under control. The operation of the device is said to be entirely satisfactory. Visitors of course have a practically unobstructed view all the way up as well as when reaching the top.

IMPROVEMENTS IN DECOMPRESSION OF DIVERS

In diving to locate the sunken submarine "F-4," outside of Honolulu harbor, Chief Gunner's Mate Frank Crilley of the United States Navy broke all deep-submergence records by going down to a depth of 288 feet.

The public has been amazed by this performance, and has naturally wondered how the human body could withstand the enormous pressure of the enveloping water at that depth. However, that record does not outstrip the possibilities of our physical endurance. No less an authority than Prof. J. S. Haldane, M. D., F. R. S., has declared, "It would seem probable that a man supplied with air in the usual way might dive to about four hundred feet!" Why, then, is it that so many under-water workers have heretofore lost their lives through asphyxiation, paralysis, etc., after dives at much more modest depths and following their return to the surface in apparently sound conditions? In answering this we shall tell how Crilley and his mates have done the work they have, and, at the same time, we shall acknowledge our indebtedness to that committee, instituted by the British Admiralty some years ago, which blazed the way to our present fuller understanding of the physiological circumstances involved in pressure work, whether it be that of the diver or the sand hog in the caisson. The human body is decidedly complex and all parts of it are not reached by the arterial circulation in the same period of time. The capillaries carry the blood much more slowly than do the active arteries of the main circulation, and, again, the tissues fed by the capillaries take up the blood at a still more sluggish rate. Reversing this process, the blood that has reached the tissues returns to the venous ebb of the main circulation last, and this may mean a lag of an hour or more under some conditions. Let us see what is the possible outcome of this tardiness.

When a diver breathes air under pressure, the blood in the cells of the lungs absorbs the air under that pressure—both the oxygen and the nitrogen—and the arteries carry it into the body. The longer the man is under pressure the farther the absorbed gases will be carried into the system by the stages we have already described. The higher the pressure the more serious this becomes as the body reaches general saturation. Now a considerable part of the oxygen undergoes a chemical change through its action upon the body substance, but not so with the nitrogen, and all that is absorbed in the system must again pass out by the circulation in such fashion that the gas shall not have a chance to produce bubbles. The deeper the nitrogen, carrying with it its initial pressure, penetrates the tissues the longer the time required to make sure of its retreat in its soluble union with the blood.

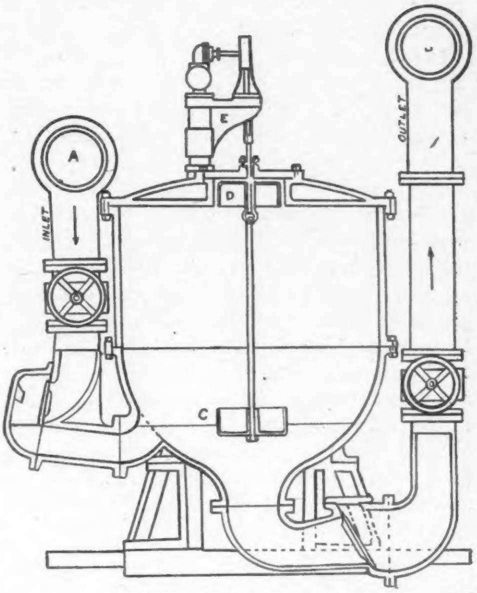
If nitrogen bubbles form through a diver's sudden ascent or decompression, and those bubbles press upon nerve centres or grow in volume enough to choke the heart and thus block the normal life stream, then paralysis or death, as the case may be, will follow. While the general circulation will quickly adjust itself to lessened pressure, the capillaries and the outlying tissues are much more tardy and the welfare of the diver hinges entirely upon the time devoted to his decompression But the British investigators established, among other things, this fact of prime practical importance—something of the utmost commercial value. No matter how deep the diver had gone or the length of time of his stay on the bottom, it was perfectly safe to bring him up quickly, at the rate of a foot a second, to a depth corresponding to half of the total absolute pressure to which he had been subjected. For instance, if he had been down to a depth of 175 feet, with a hydrostatic pressure of 75 pounds and an atmospheric pressure of 15 pounds, making a total of 90 pounds, it would be perfectly proper to bring him up to a point where the combined pressures did not exceed 45 pounds, or let us say, 70 feet below the surface. This sudden rise of 105 feet would still insure against the formation of nitrogen bubbles in the body, while it would get the man out of the more dangerous pressure zone below.

Were he brought up slowly from 175 feet, as was so long the practice, the greater pressure and the length of his time in it would have driven the nitrogen deeper into his tissues and thus increased the measure of his saturation. From 70 feet up, the period of decompression can be abridged by 10-foot stages of ascent, and these concluding steps or pauses are lengthened as the surface is neared —the longest halt being the last one below the

surface when the final surcharge of nitrogen is brought into the general circulation and carried out of the body with the breath. When Crilley's associate, Drellishak, led the way in this deep-water work, by going down to a depth of 274 feet, he was held, when ascending, at ten feet below the surface for more than hour. In this manner, recourse to the recompression chamber was obviated.

But so eminent an authority as William Wallace Wotherspoon, who had charge of the salvage operations on the "Empress of Ireland," where his men worked 160 feet down in very cold water, believes that a distinct advance can be made in the art by bringing the men to the 10-foot depth as now, but then to take them out of the water and to put them into the recompression chamber for decompression—thus avoiding the long suspension in the water near the surface, which must sap the vitality. He logically believes it is better to place the men in the chamber, where they can rest after getting out of their diving dress and damp garb, and, if necessary, be given something warm to drink. A sudden squall would endanger the life of a diver hanging overboard from a vessel a short distance below the surface, and practical commercial reasons would argue in favor of substituting the recompression chamber for a prolonged halt at the final stage of ascent.

Despite the extraordinary work of Crilley and his companions at Honolulu, a word of warning is due to those who prophesy that divers will soon be able to go still deeper. It must be remembered that compressed air means compressed oxygen as well, and oxygen highly concentrated in this fashion becomes a pronounced irritant when inhaled for a considerable period. Crilley, himself, developed pneumonia shortly after his last submergence, and the condition of his lungs since has been of a grave character. While science has made it possible for the human body to battle successfully with the heavy pressures of deep submergence, it has not done away with the chemical problems that must of necessity persist. An excess of oxygen will inflame the lungs when exposure exceeds certain physical powers of endurance. In this, we see one more barrier that nature interposes to man's penetrating farther into the ocean's depths. —*Scientific American.*



SKETCH OF SHONE EJECTOR.

TEST OF A SHONE EJECTOR

BY C. S. MOORE.*

The Shone ejector, a device for raising sewage by means of compressed air, has been in use more or less for nearly forty years. It may be clearly understood by reference to the above cut.

Sewage is admitted through the inlet pipe A, gradually rising in the ejector till it reaches the under side of the bell D, thus enclosing therein the air at atmospheric pressure. As the sewage continues to rise above the edges of the bell, this air is compressed sufficiently to raise the bell with its attached spindle, thus opening the compressed air admission valve E. The compressed air thus admitted exerts pressure on the top of the sewage, the check valve in the inlet pipe A closes, that in the outlet pipe B opens, and the sewage is forced out of the bell-mouthed bottom opening through the outlet valve and the raising main, to the outlet pipe B, which communicates directly with the gravity sewer. As the sewage passes out, its level falls till the cup, C, is left full of water unsupported by the liquid pressure, whose weight causes the cup to descend

*Abstract of Thesis in Cornell Civil Engineer.

pulling down the bell and spindle and thereby reversing the compressed air admission valve, which first cuts off the supply of compressed air, and then opens the exhaust valve through which the air in the ejector exhausts down to atmospheric pressure. The outlet valve falls on its seat, the inlet valve opens, and the sewage fills the ejector again, driving the air out through the air exhaust valve as it rises. The positions of the bell and cup are so adjusted that the compressed air is not admitted till the ejector is filled with sewage, and is not allowed to exhaust till the sewage has fallen to the discharge level. The spindle is attached at the top to a lever provided with an adjustable counterweight, which, acting as a balance to the weight of the cup, C, permits a range of adjustment of the discharge level from a level where the falling sewage first leaves an appreciable weight in the cup, to a level which clears the cup entirely.

In Ithaca, N. Y., two of the four collecting mains of the sewerage system are brought to an ejector station, where the sewage is lifted 8 feet by two 500-gallon Shone ejectors placed in a circular chamber 13.3 feet diameter, whose floor is 22 feet below the street. One of these ejectors was tested for efficiency, as described below.

In this plant compressed air is supplied through an air main of 6-inch cast iron pipe 4,018 feet long. Compressed air is furnished by two Rand Drill Co.'s Class B steam air compressors, connected to a receiving tank whose gauge pressure is kept between 13 and 15 lbs. The air and steam cylinders of this plant were fitted with Crosby indicators. The revolutions were recorded by a continuous counter. A thermometer cup was inserted in the flow pipe for the air cylinder jacket-water and the outflow led by pieces of rubber hose to the weighing tank on small platform scales. Another thermometer cup was inserted at the junction of the air pipes from the two compressors.

To be complete, the test required:

1. An efficiency test of the compressor.
2. An efficiency test of the air main.
3. An efficiency test of the ejector.

Since the ejector plant had to be kept in operation more or less continuously, a number of half-hour runs for the compressor test with fifteen-minute intervals, was adopted, and seven such runs were made with the compressor pumping through the nozzle. Steam and air cards were taken from each side of the compressor every five minutes, as were also readings of the continuous counter, air-tank and air-nozzle gauges, with corresponding temperatures, weight and initial and final temperatures, weight and initial and final temperatures of jacket water, and temperatures of the room and of the outside air. Seven runs were made and the average efficiency of the air cylinder was found to be 77.87%.

For the efficiency test of the air main, the same method was adopted and the same readings taken, except that the air nozzle with its gauge and thermometer was removed from the receiving tank and attached to the end of the air main in the ejector chamber, where the atmospheric temperature was noted. Five runs were made and the results were as follows: Averages of mechanical efficiency both runs, 83.05%, run number two, 48.94% efficiency for air delivered. Efficiency from steam cylinder to nozzle on ejector=83.05×.4894=40.64%. Efficiency of transmission=.4894÷77.87=62.85%.

For the efficiency test of the ejector, a three-hour continuous run was made with the ejectors performing their regular duty, the southern ejector discharging at intervals of three and one-half minutes and the northern at intervals of forty-five minutes. Steam cards and readings of the continuous counter and of the tank gauge were taken at the compressor at intervals of ten minutes, while at the ejector were taken the number of ejections and time of discharge and gauge readings just before, at the minimum pressure during and just after discharge.

It was decided to measure the volume of discharge in order to be more certain of the results, and to siphon out and measure the contents of the ejectors. It was found that the capacity was 481.5 British gallons, or 578.1 U. S. gallons, instead of the 500 gallons claimed.

The average for runs 1 and 2 of the ratios between the respective horsepower totals gave for the mechanical efficiency of the compressor 83.05%.

The number of cubic feet of air pumped per minute through the nozzle during Run No 1 having been found from the nozzle calibration curve, the energy stored therein was cal-

culated. The average percentage of these results to the I.H.P. of the air cylinders is 77.87%, which represents the efficiency of the air cylinder, taking into account the loss due to heating and compressing the air.

For Run No. 2 in the same way the efficiency referred to the air cylinder was found as 48.94%, where the efficiency of transmission through the air main becomes 48.94÷77.87= 62.85%. From the data of Run No. 3 were computed the efficiencies of the entire plant from the I.H.P. of the steam cylinder and the H.P. of the ejector computed on the basis of 4810 pounds of water lifted per each ejection through:

1. An effective lift of 8.17 feet from the inflow pipe to the end of the discharge pipe one block distant.

2. A pump lift of 15.37 feet, being the above lift plus the friction head due to forcing the sewage through 451 feet of 12-inch iron outlet pipe, which flows full during the time of the ejector discharge (about 14 seconds). This corresponds to a velocity of 7 feet per second, for which the friction head was calculated to be 7.2 feet.

3. The actual lift of 17.96 feet, being the pump lift plus the lift due to the fall of the sewage from the entering main to the top of the ejector dome (0.59 feet) plus the additional lift due to the center of gravity of the ejector contents being about mid-depth of the mass (2 feet) below the top of the dome.

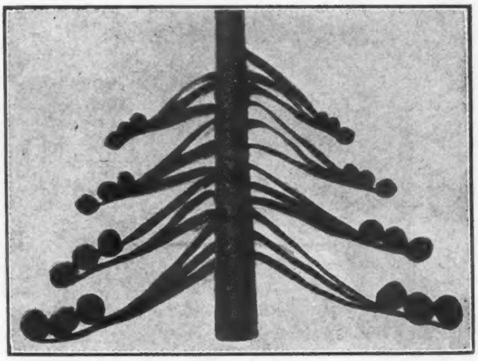
The average efficiency of effective lift was found to be 7.39%; of pump lift, 14.01%, and of actual lift, 16.39%.

From these efficiencies and the efficiency between the steam cylinder and the nozzle in the Run No. 2 (i. e., 48.94% of 83.05%= 40.64%) the corresponding efficiencies of the ejector proper were determined, as follows:

Efficiency of ejector=Eff. of total plant÷Eff. from steam cylinder to nozzle in Run 2.

The efficiency of the ejector for the actual lift (40.33%) may be considered very satisfactory. The efficiency of the total plant is low on account of the low efficiency of transmission.

It is said that the only standard of size that is uniform all over the world is that of moving-picture films, which are universally made 1⅜ in. wide.



WEAVING THE WRAPPING.

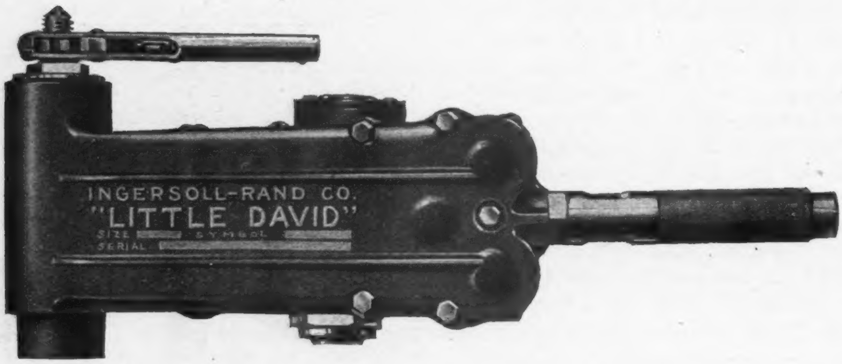
SUBERS PROCESS AIR BRAKE HOSE

The construction of this hose is clearly shown in the half-tone. In the making of what is termed wrapped hose, which has been in general use, the fabric is cut on the bias, overlapped and wrapped directly over the tube. The lap of the fabric in hose of this type varies the thickness often as much as 1/32 in., and when it is cut through a section shows that the fabric is not thoroughly impregnated with the rubber.

Under the Subers process the wrapping material consists of parallel cords combined into strips, each strip consisting of about 288 strands and being about ½ in. wide by 1/16 in. thick. Every strand is separately coated with rubber compound, which binds the strands in each strip firmly together, the impregnation of the fabric being thus very complete. The strips are wound helically about the tube or lining of the hose, there being two complete layers in each direction.

Hose of this construction shows a specially high bursting pressure, and the distorting effect of the pressure is minimized. The elongation per foot per 1,000 lb. pressure will average about ⅛ in., with an expansion of 1/16 in. in the diameter, there being no twisting or contracting.

At the present time the manufacturers of this hose, The Goodyear Tire & Rubber Company, Akron, Ohio, are confining their production of this type of hose to the standard air brake hose in lengths of 22 in., but later they expect to adapt the process to the manufacture of hose for pneumatic tools and other services.



FOR METAL DRILLING IN CLOSE QUARTERS

The drill here shown is specially adapted for working effectively close up to some obstruction and in places inaccessible to the usual types of rotative pneumatic tools. As to this point it is sufficient to say that the distance from the outside of the case to the center of the drill spindle is only 1 5/16 in.

The motor is of a novel three cylinder design operating in a constant bath of oil. The valve is of the rotary type and is gear driven from the pinion of a three way crank shaft. This crank shaft is operated by three ratchet levers which directly connect the pistons to the drill spindle, one or another of these levers being always in the driving position, so that the rotation is steady and constant. The feed when drilling is by means of a hand operated ratchet as shown. The drill has a No. 4 Morse taper socket and is rated for drilling up to 3 in. diameter, and for reaming and tapping up to 2 in.

This is a recent addition to the "Little David" line of pneumatic tools manufactured by the Ingersoll-Rand Company, 11 Broadway, New York.

AUTOMOBILE COSTS

On June 1st, of the present year, the number of automobiles in the United States for the first time reached 2,000,000. Figuring on an average of four persons to each car, which is conservative, there are 8,000,000 people in this country in daily enjoyment of motoring. To run 2,000,000 cars for one year requires at the very least 1,000,000,000 (one billion) gallons of "gas," worth $130,000,000; 20,000,000 gallons of lubricating oil, worth $8,000,000; 12,000,000 tires, worth not less than $16 a piece, or $192,000,000; accessories and extra comforts, goggles, gloves and caps, at $50 per car equals $100,000,000; garage charges on short tours (exclusive of gas and oil) $100 per car per year, $200,000,000; repairs made necessary by wear, tear and accident (exclusive of tires) $50 per car per year equals $100,000,000. Total running expenses for all cars in use, $730,000,000. Add thereto the value of the 600,000 new cars purchased during the year, at an average price of $750 equals $450,000,000, we get the immense total of $1,180,000,000 spent in a single year (1915) on the sport of motoring.

COMPRESSED AIR CLEANS CONCRETE ROAD SURFACES

On certain parts of the California highway system now under construction it has been found that before the surfacing oil could be applied, sufficient dust had formed on the concrete base to interfere with the proper bonding of the oil. After some experimenting a compressed-air apparatus was improvised which satisfactorily removes all dust and loose particles on the surface, it is stated, without requiring any extra trips over the road.

The device consists of a small air compressor mounted on the oil truck itself and geared to its main driving shaft. From the pump compressed air is conveyed to a 1¼-in. pipe fixed horizontally about 2 ft. above the road surface and 2 ft. ahead of the oil spreaders. This pipe is perforated by 1/32-in. holes spaced 1¾ in. apart. The air is delivered at a pressure of about 30 lb. per square inch and is said to drive off a continual cloud of dust even when working over a surface on which ordinary inspection shows no appreciable quantity of dust particles.

MAINTENANCE OF PNEUMATIC TOOLS IN RAILROAD SHOPS

At the convention of the International Railway General Foremen's Association, Chicago, July 13-16, the following was contributed concerning the care and maintenance of pneumatic tools in railroad shops.

J. J. Sheehan (N. & W.)—When the delicate construction of the working parts of the pneumatic motor and hammer and the narrow margin between efficiency and inefficiency are considered, it will be found that there are no tools in the shop that receive harsher treatment.

TO HAVE CLEAN AIR.

Facilities must be provided for the removal of water and dirt from the air before it enters the pneumatic machine. The removal of water can be accomplished by having a suitable sized settling tank provided with a drain valve, close to the point of operation. The most effective strainer for keeping the dirt out of the tool is that made of a double thickness of muslin placed in the air line back of the tool. The pneumatic tools must be kept properly lubricated. On the Norfolk & Western a satisfactory and cheap lubricant has been found in mineral lard oil, one containing marked emulsifying properties. Drills and hammers should be standardized as far as possible, both in styles and sizes, as it makes the maintenance easier and a smaller number of repair parts are required.

HOLDING DRILLS WHEN REPAIRING.

A simple arrangement for holding air drills while they are being repaired consists of a plain screw jack which has outlived its usefulness as a jack. The handle of the drill may be placed in the hole in the head of the jack and clamped with a set screw inserted at the top of the jack. This will readily permit of holding the drill firmly in any one position desired. It is important to know, after a drill has been overhauled, what per cent. of its rated energy it will exert. Fig. 1 shows a method of making a rough test for this purpose. A hydraulic jack is placed in a frame in which is placed the pneumatic drill. A hardened friction ball is placed in the drill socket and runs in the corresponding friction bearing in the top plate of the frame. The pressure cylinder of the jack is connected to the gage at the top of the frame. After the motor is

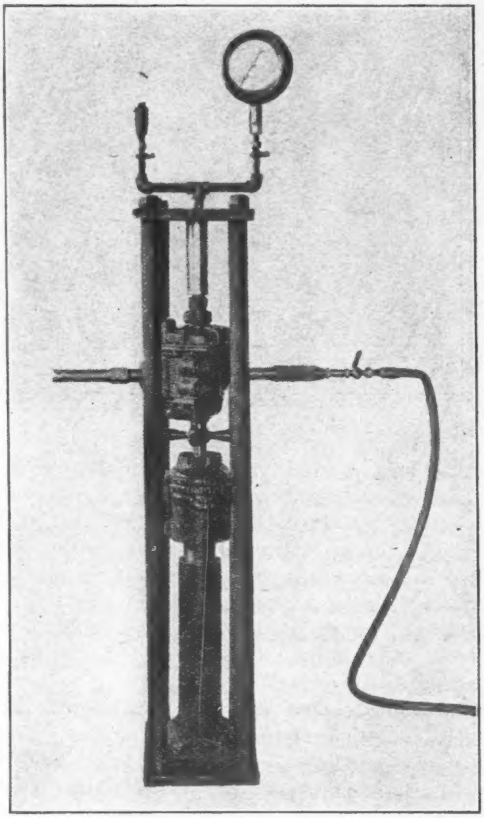


FIG. 1.

started the feed screw is screwed down on to the jack, increasing the friction of the ball in the socket, thus giving a combination of torque and thrust, exactly what occurs in feeding a twist drill. The area of the contact between the ball and the roughing surface may be regulated to give the friction desired. If the record of a drill of a particular class when new is 800 lbs. on the gage, this will be considered 100 per cent. efficiency. All other tests of the same class of drill are compared with the original record, and no drill is allowed to pass below 75 per cent. A drill failing to meet the required pressure is thorough-

CORRECTING FOR WEAR.

ly examined for wear. In many instances the piston will be found to have been worn. It is expanded, by heating, .002-in., then a turned plug of the required diameter is inserted and the piston allowed to cool on the plug

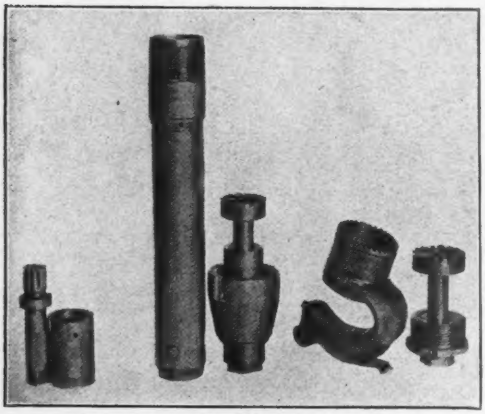


FIG. 2.

The plug receives the heat from the piston, and after it is sufficiently cool, it can be easily removed, leaving the piston expanded the proper amount. Cylinders have also been closed on certain classes of drills by pressing through a block bored to the required size. This has produced satisfactory results.

In the pnuematic hammers it is found that if the valve casing is worn .002-in., the hammer will be unfit for service. In order to locate the difficulty in this respect a new valve is kept at hand to try the hammers. The valves are purchased .002-in. over size, thus allowing a certain amount of reaming to put them in working condition. It has also been possible to take worn valve casings and roll them in a sheet iron roller, closing them a sufficient amount to put them in serviceable condition. The joints between the head and the cylinder, and between the head and the valve casing, should receive close attention. When they become uneven and leak the facing tools shown in Figs. 2 and 3 are used to correct the trouble. The feed nut for the facing tool serves as a guide.

John B. McFarland (N. Y. C. & St. L.)—The air motors for the use of the boilermakers are kept in the boiler shop, and those for the machinists are kept in the tool room. Once a week they are filled with lubricant and inspected. The hammers are cleaned and oiled once a day when in use. We have overcome trouble with broken tangs on the square chuck sockets by cutting off the left-hand thread on the chuck, replacing it with a right-hand thread, and screwing on a nut. The other end of the nut is made to fit the threaded end of the motor, the nut tightening on a shoulder at the same time that the taper shanks tighten in the motor sockets. With the chuck fitted in this way it is possible to drive a square socket tool to the capacity of the motor.

In the small hammers a bushing with a taper hole is used, and a taper shank is made on all tools. The bushings are reamed out with a No. 2 Morse taper reamer, which leaves a hole about ¾ in. on the large end and allows the use of ¾ in. octagon chisel steel for tools. This has stopped the breakage of shanks on such tools. A bushing will last from six months to a year before it becomes too large to impair the stroke of the hammer. This has been tried on large hammers with good results.

PROPER SELECTION OF PNEUMATIC TOOLS.

E. G. Nabell (Southern Ry.)—In selecting pneumatic tools, the economical operation and the cost of maintenance should receive the first consideration, not the first cost. As a means of producing better maintenance and higher efficiency from pneumatic tools the operators should be educated to use the tool that is best adapted for the work at hand, and to take proper care of the tools, particu-

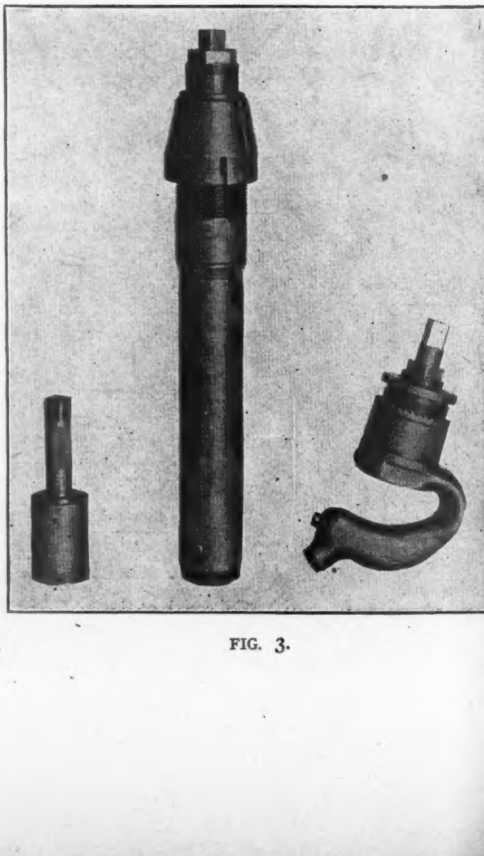
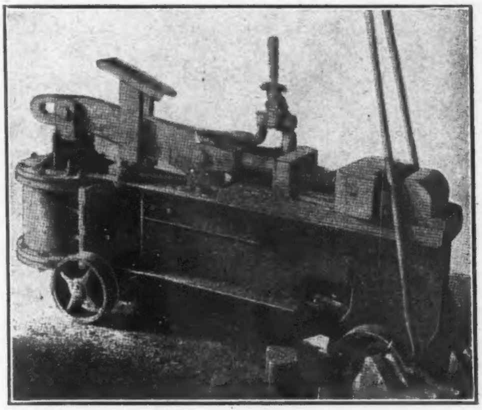


FIG. 3.

larly with reference to dropping them or striking them with a hammer, or allowing grit or any foreign substance to get into the throttle of the machine when it is not connected to a hose. All pneumatic tools should be inspected and tested at regular intervals, cleaned and thoroughly lubricated with a good grade of lubricant. By keeping a close record of the repairs to the tools it will be possible to determine just what and how many repair parts should be carried in stock. When the tools are sent to the tool room for repairs they should be taken apart and thoroughly cleaned. An air hammer, when not in service, should be kept submerged in a good quality of light clean oil to insure the thorough lubrication of all parts and prevent rusting. Where possible, it is desirable to confine the repair work on pneumatic tools to one mechanic who has become thoroughly familiar with the tools.

August Meitz (M., K. & T.)—It is a good policy to adopt a standard for pneumatic tools on any one railroad system. This would reduce the cost of repairs and maintenance about 50 per cent, as well as reduce the expense for repair parts to be carried in stock. The operators should be educated in the matter of the proper use of pneumatic tools; that is, they should use high-speed motors when they are required, and slow-speed motors when they are required. Much damage is done to the motor, as well as to the tool, when this is disregarded. Good engine oil should be used to keep the motors lubricated, and it will also be found to pay to use some light grease, such as Keystone or vaseline, in the crank case. The motors should be kept in good repair and inspected regularly. It has been found to be good practice to place the hammer, after it has been in service, in a solution of gasolene and signal oil, mixed half and half, as small particles of rubber from the hose lining frequently lodge in the chamber between the handle and the throttle valve. The gasolene will cut the rubber, and by blowing the hammer out with compressed air the refuse and foreign substances will be removed.

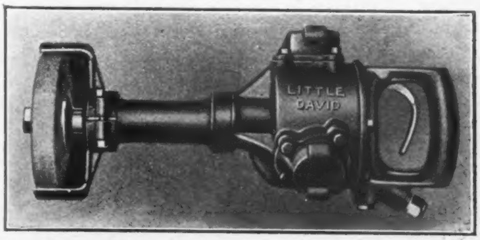
In the list of patents for the week of July 27 there is a series of six for apparatus for the pneumatic conveying and handling of ammunition. The claims of the six patents number 231.



A PORTABLE PNEUMATIC BULLDOZER

The half-tone here reproduced from *Railway Age Gazette* shows a home-made pneumatic tool such as may be expected to be found in railroad shops where there is always a ready supply of compressed air. This is a portable pneumatic bulldozer made in the Rock Island Railroad shops, Silvis, Ill. It is a very serviceable tool, normally for blacksmith work, which can be run around anywhere and connected with the air line as most convenient.

The air cylinder is at the left, the piston rod attaching to the long arm of a bell crank which operates the ram or plunger. Various bending forms may be used and punches of any size or shape. The body of the machine is a piece of heavy I beam which is mounted on small cast iron wheels. The lower part of the beam is notched out near the front to allow short cramping of the front wheels for turning in close quarters.



A PORTABLE PNEUMATIC GRINDER

The half-tone shows a handy portable tool especially adapted for trimming the surfaces of heavy castings and similar work in foundry and machine shop, a recent new output

of the Ingersoll-Rand Company, 11 Broadway, New York. This is an air operated tool using the usual shop air pressure, carrying an emery wheel up to 8 in. diameter at speeds up to 3,400 r.p.m. The motor is a three cylinder engine with connecting rods attaching by ball bearings to a single crank on the central spindle. This spindle has a ball bearing on each side of the crank and another close to the grinding wheel. This is all enclosed in a dust proof aluminum case with a constant bath of oil for the motor. The valve is of the rotating type, forming a detail of the crank-shaft and working in a renewable bronze bushing. No gears or pinions are used in the construction. The entire operating mechanism is readily accessible, the loosening of six cap screws removing the handle end and exposing the entire interior. The cylinders are renewable independently of the casing and are interchangeable, as are also the pistons and rods. The lugs outside the cylinders will be noticed; these being provided to take the knocks if the tool is carelessly thrown around.

JACKHAMER DRIFTING COSTS

At the Colby iron mine, Bessemer, Mich., drifting is done by use of Jackhamer auger machines, using two men for one machine. These two men do only the drilling and are followed by a blasting gang and a tramming gang for each drift of the six different headings where this system is used. The size of the drift outside of timber is 8x9 ft. During the period in question 2547 ft. of drifting was accomplished in 112 shifts, which is equivalent to 11.3 ft. per man per shift. The costs per foot are as follows:

LABOR.		
Miners	$0.412	
Trammers	.990	
Timbermen	.360	
Trackmen	.121	
Blasters	.116	
		$1.999
SUPPLIES.		
Lagging	$0.094	
Timber	.210	
Explosives	.330	
Light, steel, shop labor, etc.	.060	
		.694
Total		$2.693

The foregoing figures include cost of breaking the ore, tramming it to the chute, timbering the drift, laying track and necessary supplies for the same except the cost of rails.—*Engineering and Mining Journal.*

YOU CAN'T TELL ME NUTHIN

BY BERTON BRALEY.

"You can't tell me nuthin'," the pitboss, he says;
"You can't tell me nuthin' a-tall,
I don't need advice from no hunkies like you—
An' if I do need it, I'll call;
I guess I kin tend to my business o. k.
Without no attention to nuthin' you say.

"You can't tell me nuthin'," the pitboss, he says;
"I reckon I'm on to my job,
An' I'll thank you to keep your suggestions to home,
You miser'ble ignorant slob;
I haven't no time fer to hear your idees;
I guess I'm the boss an' I'll do what I please."

Yes, that was the way that the pitboss come back
When I made a suggestion, polite,
But the Super he heard what the pitboss had said
An' he wasn't contented—not quite.
"Hold on there," he says, when the pitboss got through,
"I guess I'll horn in with a brief word or two."

"They can't tell you nuthin'," the Super repeats,
"Then Lord help you, brother," says he,
"For the guy who imagines he's knowin' it all
Aint quite the right pitboss fer me.
If YOU can't learn nuthin' from no other man,
I'll go get a feller for pitboss who can.

"We haven't no use fer the feller," he says,
"That thinks he has knowledge to burn,
Who scorns all suggestions that comes from his men
An' won't never listen an' learn.
They can't tell *you* nuthin'—them words makes me tired,
An' I'll tell you something right now—you are fired!"

Coal Age.

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Established 1896

W. L. SAUNDERS, - - - - - Editor
FRANK RICHARDS, - - Managing Editor
CHAS. A. HIRSCHBERG, - Business Manager
W. C. LAROS, - - - Circulation Manager

PUBLISHED MONTHLY BY THE

Compressed Air Magazine Company

Easton, Pa.

New York Office—11 Broadway.
London Office—165 Queen Victoria Street.

Subscription, including postage, United States and Mexico, $1.00 a year. Canada and abroad, $1.50 a year. Single copies, 10 cents.

Those who fail to receive papers promptly will please notify us at once.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

Entered as second-class matter at the Easton, Pa., Post Office.

Vol. XX. SEPTEMBER, 1915. No. 9

CONTENTS

PNEUMATIC ACTIVITIES IN NEW YORK

It seems to be worth while to note one or two local indications of the part which compressed air is playing in the constructive engineering operations at present in progress in New York City. The larger operations, the driving of the tunnels under the East River, with compressed air performing the threefold function of resisting the water pressure, of pumping out the unavoidable inflow and of operating the rock cutting apparatus, is a familiar story which requires no retelling.

On the land in connection with the same work there is constant employment of compressed air in various ways. One of the new subway lines under construction in lower Manhattan runs for a considerable distance up Greenwich Street and immediately under the tracks of the elevated railroad which follow the same street for the entire length of it. At the lower end of the street the subway excavation is in solid rock, which gives steady employment to a lot of Jackhamer drills which seem to have entirely superseded the old heavy reciprocating types. Farther up there is more earth than rock excavation, but whatever the nature of the ground all operations are carried on without any interruption of the traffic overhead. This means not only that the tracks above have to be temporarily supported but also that all the pillars have to be extended downward or to be rebuilt upward from the level of the subway floor.

This rebuilding of the structural supports has required the removal of much of the original steel work, to be replaced by other columns, girders, etc., differently arranged, and in this destructive work compressed air has been called to render its efficient aid in another way. Oxygen, as we all know, comes to us now commercially through the air liquifying process, and the oxyhyphen (in this case Blaugas) torch has been doing its wonderful work of steel cutting here quite extensively, so that it has made a brilliant daily display of itself where in use.

While all this subway construction work has been proceeding rapidly without interrupting the elevated travel it has happened, to complicate matters, that a great and important work of rearrangement and reconstruction of its track for express service has been carried on by the elevated railroad company. This has required much construction entirely new,

the details of which we need not go into here, and in this work pneumatic tools, drills and riveters especially, have worked with their usual efficiency. It is not easy to see how all these things could possibly have been done without the aid of compressed air and also of highly compressed management.

SOME NEW BOOKS

Attention is called to the following new and entirely up-to-date books which should be of interest and value to our readers, published by John Wiley & Sons, Inc., New York.

Gas Power, by C. F. Hirschfeld, M. M. E., and T. C. Ulbricht, M. M. E. 219 Pages 7¾ by 5¼ in., 60 illustrations, Price $1.25 net.

This book gives a good insight into the theory of the heat engine problem, the use of fuels as gas producers, the development of gas power, details of gas generators and modern types of gas and gasoline engines. Every automobile owner or driver should be well versed in the working of his engine and a little study of this book should be of great assistance.

Mechanism of the Steam Engines by Walter H. James and Myron W. Dole, 180 pages, 9 by 6 in., 183 illustrations, Price $2.00 net.

Electricity and compressed air have not in the least belittled the steam engine as the supreme prime mover, and a knowledge of both theory and practice as applied to steam was never more essential to the man who aims at success in power application. This book treats of all types of engines from the simplest horizontal to the latest turbine. It treats of the use of the indicator, discusses valves and valve setting, governing and controlling devices. It is essentially practical rather than theoretical in its makeup.

Power and Power Transmission, by E. W. Kerr, M. E., 403 pages, 9 by 6 in., 325 illustrations, Price $2.00 net.

This book covers a broad field, and the fact that it has already gone to its third edition is a practical endorsement of its value. It treats of the elementary details of all machinery: shafting, bearings, friction and lubrication, pulleys and belts, toothed gearing, screws, cams, links, etc. Then it gives a very complete treatise on the steam engine in all its varieties and applications, also its various appurtenances and accompaniments. A third section is devoted to pumps, gas engines, water power, air compressors, air motors, etc. The various chapters are supplemented by examples to be worked out.

Mechanical Refrigeration, by H. J. Macintire, M. M. E., 356 pages, 9 by 6 in., 121 illustrations, 51 tables, Price $4.00.

This is a work representing an unusual amount of labor in its preparation. Many of the illustrations in the list are large, inserted, folded diagrams embodying curves of various data. The types of refrigerating machines are described, their construction is discussed and the auxiliaries treated of. The theories of mechanical refrigeration are stated and the choice and properties of refrigerating media. Then comes the testing of the refrigerating machine with several interesting chapters on ice making, cold storage, cooling of air, cooling of liquids and solids and other applications of refrigeration. The appendix gives a collection of pertinent examples, tables and data.

A CAT CATASTROPHE

A peculiar and somewhat mysterious accident occurred recently in the building of the Society for the Prevention of Cruelty to Animals, New York City. A rectangular steel tank, 5 ft. high, 5 ft. wide and 10 ft. long, used for asphyxiating cats and dogs exploded while in use, blowing out some of the windows of the building, but doing little other damage.

The cats to be killed are placed in the tank and illuminating gas from the city mains is then discharged into it, expelling some of the air. In this operation there is more or less mingling of the gas and air, and an explosive mixture is thus formed. In this case the mixture was ignited, causing the explosion; but the question is as to what fired it. In the reports in the daily papers it was suggested that the sharp claws of the cats clawing the sides of the tank must have struck a spark which ignited the charge, but this is not easily credible. Cats' claws are not sparkers, but a cat's fur when properly agitated is one of the best known sources of electric sparks. It is easy to believe that when the gas was first admitted the cats, smelling the gas and suspecting that something was going on, began to jump around, or perhaps to fight, and rubbing against each other could easily have furnished an igniting spark.

THE AMMONIA FUNCTION IN REFRIGERATION*

BY ALBERT JOHNSON.

Let us see how anhydrous ammonia becomes a conveyor of heat. When one pound of anhydrous ammonia has passed through the regulating valve into the low-pressure pipes it remains a liquid until it can grab hold of from 500 to 600B.t.u. of heat. Then the pound of liquid changes into a pound of gas. But it refuses to change from liquid to gas until that much heat leaves the room and enters the liquid ammonia on the inside of the coils, thereby turning it into gas.

The changing of the liquid into gas is what absorbs the heat. Therefore, it is always necessary to have plenty of liquid ammonia within the low-pressure pipes.

Do not, under any circumstances, allow gas to pass through the regulating valve, for then you only add heat to your rooms instead of subtracting it. Remember, the gas is the loaded vehicle, while the liquid is the unloaded vehicle, being empty. The liquid has plenty of room for heat units, but the gas has little room for heat units, since it is already loaded with them. It cannot carry any more. So it is well to watch and see that only liquid passes the regulating valve into the low-pressure pipes.

Bear in mind that it requires heat to vaporize ammonia—the more heat, the quicker the evaporation; whereas, the less the heat, the slower the evaporation, which explains why "sharp freezers" are so apt to fill up with liquid in abundance, while the rest of the system may be suffering from the lack of liquid.

After the liquid has been changed into vapor by the heat, it has practically spent its energy as a refrigerant, for the gas has obtained its full load of heat and is ready to carry it away.

So far the ammonia, or vehicle, has been "running down hill," requiring no power. At the bottom of the hill is the loading platform where the heat is taken aboard. After this it's an uphill pull, and a good strong horse is required to pull it up to the unloading platform. The horse may be called a "refrigerating machine."

The machine gets behind the heat-laden gases in the frosted low-pressure pipes and pushes them up to the top of the hill to the unloading platform, or ammonia condenser, where the loaded gas is changed back into a liquid. Just at the moment when the gas becomes a liquid it releases or dumps out the heat that it formerly picked up in the rooms, and the water in the condenser then absorbs the released heat units and carries them away.

Thus we see how necessary is the refrigerating machine to push the loaded vehicle, ammonia, along the uphill grade of high pressure direct to the top, or unloading place, at the condenser. But that is all it has to do, for the real work of freezing is performed by the ammonia, not by the machine. The initial as well as the final operation is done by the vehicle called ammonia, which must not be forgotten.

Thus you can readily see how anhydrous ammonia actually becomes a so-called vehicle for removing heat units from insulated rooms and carrying them, with the aid of the refrigerating machine, upstairs or downstairs, around corners and angles to condensers, there to unload its heat. Then it goes back to repeat the operation.

A regulating valve controls the flow of liquid ammonia into the low-pressure pipes. That is all it is there to do. It cannot do any freezing, since only the ammonia does that. I mention this because, way back in the early days of this industry, somebody misnamed that valve—the expansion valve—without thinking of the consequences.

Ever since then many operators got the erroneous idea that this valve actually did the heavy work of freezing, and they would fondle it and handle it, fuss over it and play with it, sometimes resetting it twenty times a day, then listening to hear the gas gurgle or spit through it. The misnaming of this valve has cost the owners of plants hundreds of thousands of dollars in time lost fooling with it and in lack of efficiency caused by relying on this valve during critical moments of climbing temperatures, when the receiver should be watched instead. It is best to call it a regulating valve, to save confusion of ideas, much money and false impressions.

When I speak of heat-laden gases in suction pipes it may surprise you. Try to put your hand on a frost-covered suction line and im-

*Read before the American Meat Packers' Association.

agine it contains real heat. It actually does, and lots of it, only it is called latent heat, or insensible heat. A thermometer cannot register it, nor can you feel it by touch. But it is there just the same. Apparently, the pipe is very cold, for it is usually covered with frost, yet the cold gas inside of that pipe will deliver heat enough to warm up enormous quantities of condensing water from 10 deg. to 30 deg. Fahr. per pound.

We learn how the vehicle ammonia is relied upon to take the initiative in the work of removing heat. It is essential to work with not only dry, but pure ammonia. Note the difference between dryness and purity, for volatile hydro-carbons may exist in the liquid itself, which cause abnormally high pressures. Such foul gases refuse to liquefy and they fill up the condensers.

These bad gases must be blown away. Hydro-carbon gases are both colorless and odorless, which makes them hard to find. They are hidden, and like latent heat we know them by the effect they produce when they refuse to liquefy, causing excessive fuel bills or power bills and great ammonia consumption.

It has been estimated that in order to purge 15 pounds of uncondensable or hydrocarbon gas from the system you lose 85 pounds of pure gas, because the two are closely associated or intermingled, so that when the purge valve is opened the good as well as the bad gases are liberated unavoidably together.

GOOD AMMONIA REQUIRES NO PURGING.

Good ammonia requires no purging, for good ammonia is free from volatile hydrocarbons. The evaporation test does not disclose the presence of volatile carbon compounds, for they evaporate together with the ammonia. The working test seems to be the most reliable. The test for air in shipping cylinders means little as to quality and has the disadvantage of being deceptive.

Ammonia is like fullers' earth, because both require a working test to prove their effectiveness. In both cases results count more than analysis. A chemical report on fullers' earth is about as valuable as a chemical report on anhydrous ammonia. However, in making an exhaustive examination of ammonia a thorough chemist will demand to see the raw material as well as the finished product. In testing cement, for instance, a thorough chemist will also examine the clinker or raw material as well, in order to obtain data for proper valuation. The clinker may be overburnt or underburnt, and the chemist is right in demanding a sample of the raw material.

The purchase of anhydrous ammonia should be like the hiring of a man. You expect a man to perform some service and keep on doing so. In purchasing ammonia you must expect it to serve you by picking up or absorbing all the heat units possible and unloading them in large quantities day by day, without getting tired or worn out on the slightest occasion. Remember, you do not buy ammonia like other merchandise, to be sold to others from the shelf. Instead of that, you invest your money in an article that must work for you day and night, and produce results in heat-carrying capacity. For, to produce one ton of refrigerating duty the vehicle, ammonia, must fetch and carry away 288,000 B.t.u. of heat from insulated rooms in the shortest time possible, and that is why the question of ammonia as a heat vehicle is so serious as to affect the profits in a refrigerating plant.

A VISIT TO AN ALASKA GOLD MINE

The following account of a formal visit to a mine in full operation in Alaska, taken from the Alaska Daily Empire, published at Juneau, is unusually realistc and should be read with interest.

The party of legislators, mining engineers and representatives of the press which took advantage of Supt. P. R. Bradley's invitation to inspect the workings of the Alaska-Juneau mine and mill yesterday, returned to town with high grade specimens of ore, a fund of information and words of praise for Mr. Bradley, whose patient courtesy had made the trip possible.

The party left the Alaskan in autos at 10 o'clock sharp, were supplied with slickers and other apparel for their comfort and hoisted to the motor railway. There they boarded cars and were sped along the scenic heights, through the 6500 foot tunnel and out into the open stretches interspersed with lesser tunnels, until they entered the electric lighted mining tunnel proper.

A mile or so of this brought them to the hoist which lifted them up the 55 per cent. shaft to the surface where they looked out across Gold creek basin at the buildings of the Ebner property, the Perseverance toward

the head of the stream resembling a fort on the heights, the glacier at one side, and lastly at the crumbling ruins of the old stamp mill where the Alaska-Juneau mine had first been picked at—a scene, as Senator Millard afterwards said, which caused him to see in fancy the first prospector toiling up the rough creek bed with a pack on his back, and in his hand carrying a pick for a staff.

Level No. 2 was next visited, this being a wide irregular chamber, apparently covering a couple of acres of floor space, out of which the ore had been taken and where a hive of men were sorting and wheeling pay rock to the chutes, their lights flickering like June Bugs in the darkness while the deafening thud of drills eating their way into the face and roof of the chamber gave a Gulliver effect to the place.

But the vault on level No. 4 was by far the most impressive sight of the day. Here in one place the ore had been removed to a height of 60 feet from the chute to the ceiling and for the matter of 150 feet in diameter, and as one looks down into the hollow and across at the bobbing lights of the miners on the farther side, it has the appearance of a vast underground theatre, dimly lighted and weird. Senator Hubbard suggested it would be a good place for the next Legislature to meet.

After inspecting the engine room at the mouth of the mine tunnel where the new 750 h. p. Ingersoll-Rand engine, "running as smooth as a watch" and fed from the power 12 miles away, furnishes the compressed air and retransmission for the hoists, etc., the party descended to the mess house and partook of a nicely prepared dinner.

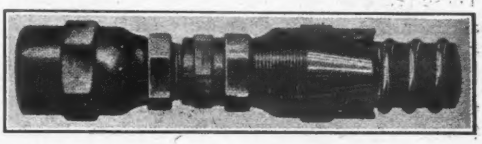
[It will be remembered that in our April issue, page 7575, we showed the big air cylinder of the compressor above referred to, mounted on a truck and drawn by ten heavy horses.—Editor C. A. M.]

Senator Aldrich directed his remarks to a comparison of the home-like atmosphere of the Alaska-Juneau mess house with that of one at a mining camp at Berner's Bay in the early days, saying that he noticed that the waiters were able to serve the table here with slippers on their feet, while at the camp he had reference to, the men sat at the table with their slickers on, the water dripping from the ceiling into the soup and beans which the waiters in gum boots served to them. Representative Moran enlivened the after-dinner smoke by reciting "The Kobuk Maiden," a poem with an Arctic tang ending, "And the waters of the Kobuk rippled onward to the sea."

Prof. Cory gave a very interesting discourse on the present application of machinery to mining in particular and the work of the world in general, stating that its development had now reached such a stage that "Co-operation is the whole story with the water falls of nature doing the work—one continuous horse power being equal to that of 90 men."

Returning to the mill, the party, guided by Mr. Bradley, Supt. Richards and Foreman White, were shown the minute workings of its fifty stamps, which work up 600 tons per day and watched the black sand which carries the gold dripping off of the broad shakers.

Descending the path to the office, the sightseers visited awhile there, and were then carried to the ferry landing on the company gas boat.



A NEW COUPLING FOR AIR HOSE

The half-tone, made partly in section, shows the essential features of a coupling for rubber hose put out by the National Hose Coupling Company, Peoples Gas Building, Chicago. Scarcely a word of explanation is required. The end of the hose is slipped over the conical end of the nozzle as shown and then the sleeve or socket is drawn over it by the screw movement, causing the hose to hug the cone and make a joint tight and secure. The only tool required is a wrench.

THE HABITS OF THE WINDS

Thirty-five years ago, while making a four months voyage, I was frequently impressed by the unerring accuracy with which Captain Crosby, one of the best known captains sailing from New York, forecast the state of the weather. In reply to my question, he answered: "Doctor, as a result of fifty years of seagoing life, I can assure you that almost invariably, I might say without exception, the wind in its shifting follows the course of the

hands of a clock, that is, from left to right Of course," he added, "one cannot say how long the wind will remain in any one quarter, but when it changes it will, almost without exception, take the course I have stated. For instance, if the wind is in the northeast, instead of going to the north and then to northwest, it will on the contrary go over to the east, southeast, south, sotuhwest, west, and finally reach the northwest." When I asked him why that should be he said he had never been able to obtain an answer to that, but that it was an absolute rule as far as the experience of his life went.

One other observation I have made through all these years, although it is not by any means as exact as the first, is that the winds have a fairly accurate length of time in which they remain in their various quarters. For instance, northeast and east winds are generally two or three days in duration, gradually shifting to southeast and south, then after a day's interval, or less, reaching west and northwest. These remarks apply only to the Atlantic Coast and contiguous states, and are inapplicable to the Pacific where the conditions, in some respects even more remarkable, are entirely different.—*Dr. Frank S. Abbott in N. Y. Times.*

FLEXOID AIR CONVEYERS IN TUNNELING

In starting the building of the Mill Creek sewer, which is an extensive tunnel job, at St. Louis, galvanized iron ducts were provided for ventilation in the shafts and headings. On account of the time lost in re-extending the pipe to the headings after shooting, the contractors, Thomas Connor & Sons, took up with the Bemis Bros. Bag Co., the question of supplying a flexible textile conduit. The result was a duct or tube of heavy rubberized fabric practically air-tight and water-tight, strong enough for the light air pressure, light enough to be easily and quickly handled and much cheaper than the galvanized iron.

It is made in sizes up to 24 in. diameter and normally in lengths of 100 feet with handy iron couplings. At the job spoken of there is a Jeffrey blower delivering 10,000 cu. ft. of air per min. A 24 in. Flexoid tube carries the air down the shaft, and 16 in. tubes run each way to the headings. D. H. Blanks, engineer for the contractors, estimates that just before shooting, the blower having been stopped, one man can roll up the duct for 200 ft. or more in a minute or two and that it can be replaced again even more quickly after the shooting. The Flexoid duct has been in use at St. Louis for 5 months and some of it has already been replaced on account of more or less rotting. It is considered that in dry work the life would be much longer. By the time the job is finished the entire duct may have to be replaced once, but even then the cost would be less than one-half of the cost of the galvanized pipe, besides the greater convenience and the saving of time in handling.

NOTES

A 4-in. gas main, 4000 ft. long, was recently welded at Newbern, N. C., with Prest-O-Lite gas and oxygen. The material used was standard National steel line tubing and was sent to the job with the ends beveled and ready for welding. The work was done in the trench, as it was found that faster welds could be made, joints being made in 7 to 10 min. A record of 15 joints with one torch in one afternoon was made, the apparatus being moved a distance of approximately 20 ft. after each weld. Soft steel wire of No. 8 gauge was used as a filling material.

The number of sailors who have been drowned when British warships have been sunk by submarines has caused the Admiralty to adopt a special life preserver. The device is a pneumatic collar, which each sailor wears about his neck at all times when within reach of the enemy. Ordinarily it is not inflated, and so is not in the way, but in case of mishap the wearer may place his lips to the valve mouthpiece and blow the collar full of air in a quarter of a minute. This simple device would seem to be a valuable one although evidently cheap, and should be on sale for the general public.

According to the decision in a recent suit in a West Virginia court, gasoline vapor is not a gas. The lessees under an oil and gas lease perfected a method for condensing, saving and marketing the gasoline that was wasting from the casing-head in the form of vapor, and tendered to the lessors the stipulated royalty based on oil extraction. The lessors claimed in addition thereto the minimum gas rentals,

basing their contention on the theory that the gasoline-vapor was a gas product. The court held that gasoline-vapor was not gas within contemplation of the lease, and that the lessors were entitled to royalties based on its production as a part of the oil yield of the well.

A recent application of Prest-O-Lite gas in combination with oxygen for cutting steel work was at the drawbridge of the Florida East Coast Railway, over the St. John's River at Jacksonville, Fla. In the construction of this bridge sheet steel piling having a 3/8-in. web and approximately 2 1/4 in. thick on the lock joint was driven to form the protection piers. Approximately 860 ft. of this piling had to be cut off at a uniform height and at the lock joint practically four sections of metal had to be cut through. This necessitated frequent changes in the adjustment of the blowpipe. One man did the cutting and between 40 and 50 ft. of piling was cut in 7 hr.

The change-house at the Raritan Copper Works, Perth Amboy, contains a main ventilating-pipe that is fixed along the centre of the building. Branches from it run to, and underneath, each lot of lockers. By this means it is expected that the lockers will be kept thoroughly ventilated, and in wet weather the damp clothing will be dried.

One of the air compressors at a works where I was employed had its intake in the engine room. The engineer was ordered to extend it outside in order to get it away from the heat and moisture. He did this next day, placing it immediately over the exhaust from a small non-condensing engine.—*Power.*

A flash of lightning during a thunderstorm is credited with causing an explosion in a mine shaft in South Africa which killed and injured several people. According to the report on the case, the foreman in charge of sinking the shaft had connected up his wires preparatory to a blast at the bottom of the shaft, and with his helper was being hoisted from the shaft, when the charges exploded and the two men were thrown out at the top. It is supposed that a flash of lightning during a severe thunderstorm that was raging struck the hoisting or guide ropes, by which the electricity was conducted down the shaft to some point where contact was made with the wires connected with the explosives.

The Navy Department has awarded to the International Oxygen Company, 115 Broadway, New York, the contract for the erection of a hydrogen generating plant for ballooning purposes at the aeronautic station of the navy yard at Pensacola, Fla. The company has also received the award from the Government for the installation of its system for generating oxygen and hydrogen at the navy yard at Washington, D. C.

It is estimated that six and a half million people are employed in the whole world in mining and quarrying, about one-third of them being in the British Empire. Thus digging for minerals is one of the chief industries of men, and compressed air is in this line the most active agent employed.

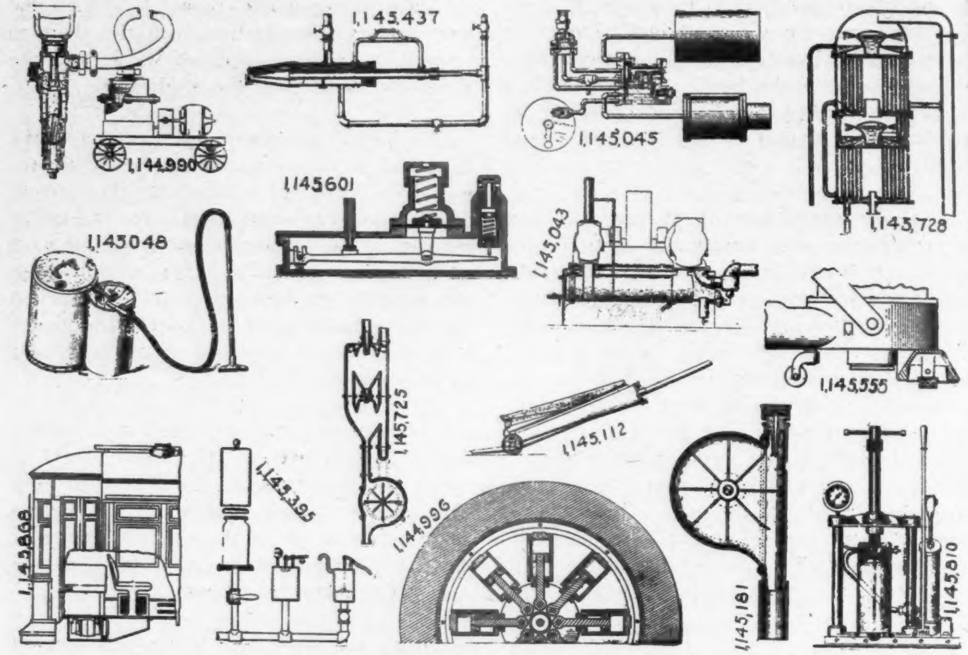
In 1912, the latest year for which detailed figures are available, the world produced about $480,000,000 worth of gold, the British Empire contributing sixty-one per cent. Australia produced ten per cent., South Africa nearly forty per cent. and Canada, the Gold Coast, India, Rhodesia and New Zealand combined, eleven per cent.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JULY 6.

1,144,990. PULSATORY PERCUSSIVE DRILL. LEWIS CONDICT BAYLES, Easton, Pa.
1,144,996. WHEEL. JOHN ARCHIE BORLAND, Cincinnati, Ohio.
1,145,043. PRESSURE-CONTROLLED VALVE. WILLIAM F. TREIBER, Corning, and EMERY L. BULKLEY, Painted Post, N. Y.
1,145,044. BRAKE-CONTROL VALVE. WALTER V. TURNER, Edgewood, Pa.
1,145,045. EMERGENCY - VALVE DEVICE. WALTER V. TURNER, Edgewood, Pa.
1,145,047-8. VACUUM CLEANING APPARATUS. THEODORE WIEDEMANN and JOSEPH H. TEMPLIN, Philadelphia, Pa.
1,145,112. VACUUM CLEANING-MACHINE. GEORGE BRAND, Brooklyn, N. Y.
1,145,144. ELASTIC - FLUID TURBINE. FRANKLIN P. JACKMAN, Marshfield, Oreg.
1,145,181. VACUUM-PUMP. CHARLES BRENT, Buffalo, N. Y.
1,145,276. PNEUMATIC PAD FOR PRINTING-PRESSES. CHARLES A. STURTEVANT, Plainfield, N. J.



PNEUMATIC PATENTS JULY 6.

1,145,395. APPARATUS FOR PRESERVING BY VACUUM. JAMES R. WERTH, Richmond, Va.

1,145,437. OIL-BURNER. SID PERRY and CHARLES A. KENWORTHY, Tenino, Wash.

1,145,555. VACUUM-CLEANER. GEORGE CLEMENTS, Chicago, Ill.

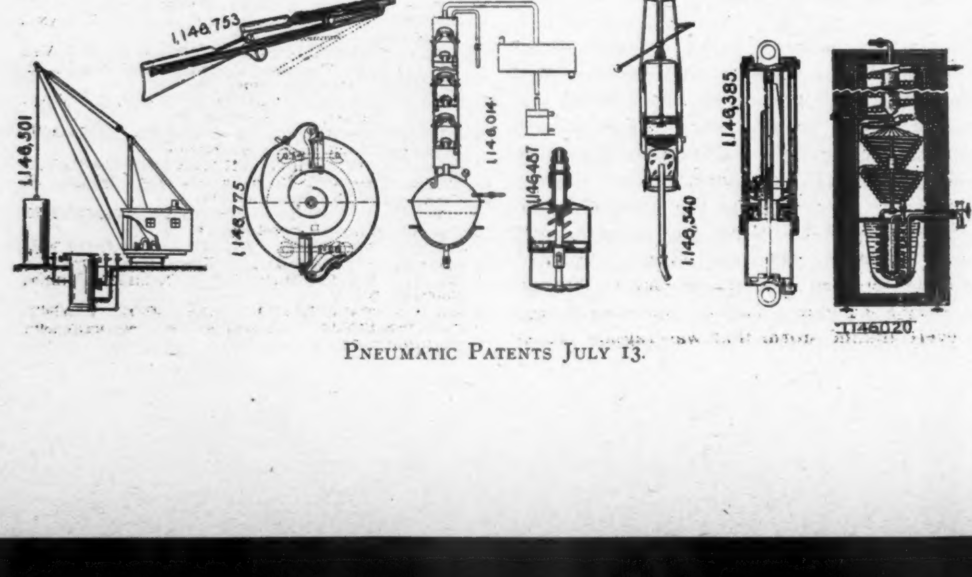
1,145,601. PRESSURE-REDUCING VALVE FOR GAS. LOUIS LEMOINE, Paris, France.

1,145,725. VACUUM-CREATING DEVICE. GEORGE C. WEISS, Pittsburgh, Pa.

1,145,728. EVAPORATING APPARATUS. WILHELM WIEGAND, Merseburg, Germany.

1,145,810. DOMESTIC VACUUM-SEALER. GEORGE BROWN SINCLAIR and SILAS E. MENOUGH, Wellsville, Ohio.

1,145,868-9. CAR-VENTILATING SYSTEM. DWIGHT I. COOKE, Chicago, Ill.



PNEUMATIC PATENTS JULY 13.

JULY 13.

1,145,948. WATER - COOLED BLOWPIPE. ADOLPH W. WAERN, New York, N. Y.

1,146,013. PROCESS OF PICKING AND SEPARATING COTTON FROM BOLLS. JOHN MEIER, Dallas, Tex.

A process of separating cotton from its burs consisting in causing bodily the bur with the cotton still attached thereto to be detached from the stem of the plant and driven forcibly *by pneumatic means* against a roughened convex surface separating the fiber from the burs by attrition between said surface and a revolving element, causing further downward movement of the burs and fiber by the combined action of the blast and revolving element and separating the burs from the fiber by action of gravity during such movement, and finally depositing the fiber and burs in separate receptacles.

fluids within the chamber, and a pump within said chamber having mechanical connection with both of said members for transferring leaked liquid to said chamber.

1,146,377. FLUID-METER. BENJAMIN M. WALPOLE, Providence, R. I.

1,146,409. FLUID-METER. HARRY S. DOLBEY, Providence, R. I.

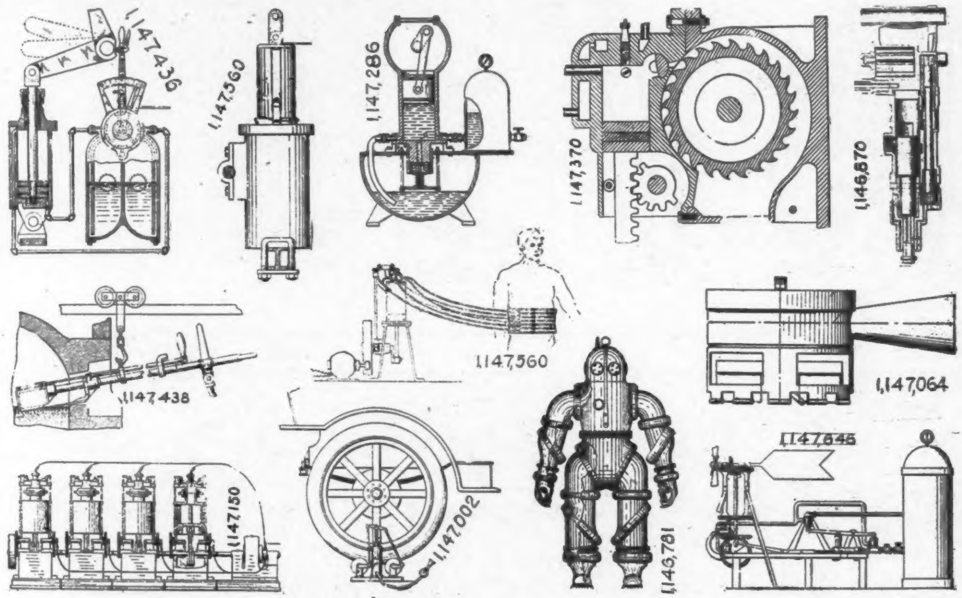
1,146,487. AIR-COMPRESSION PUMP. HENRI ALBIN JOSEPH EVESQUE, Valence, France.

1,146,501. IMPREGNATING PILES. HARRY G. JENNISON, Toledo, Ohio.

1,146,526. DEVICE FOR CONTROLLING FLUID-PRESSURE. DANIEL SCANLAN, St. Louis, Mo.

1,146 540. VACUUM-CLEANER. JOHN M. WINTER, Reading, Pa.

1,146,753. AIR-GUN. ARTHUR V. DICKEY, Seattle, Wash.



PNEUMATIC PATENTS JULY 20.

1,146,014. METHOD FOR CONCENTRATING NICOTIN SOLUTIONS. ROBERT G. MEWBORNE, Louisville, Ky.

1. The improvement in processes of concentrating solutions or extracts containing free nicotin, which consists in distilling the water off in a chamber mantained under a *high vacuum* and the corresponding low temperature to the desired point of concentration.

1,146,019. VACUUM-PRODUCING METHOD AND MEANS. AUGUST H. PFUND, Baltimore, Md.

1,146.020. AIR LIQUEFIER AND SEPARATOR. JAMES F. PLACE, Glen Ridge, N. J.

1,146,193. FLUID-PRESSURE CHUCK-ACTUATING DEVICE. WILLIAM L. MILLER, Madison, Wis.

1,146,202. ANEMOMETER. ALEC OGILVIE, Eastchurch, Sheppey, England.

1,146.284. AIR AND WATER BLOWPIPE FOR ROCK-DRILLING. FRANK T. SANDERS, Colorado, Springs, Colo.

1,146,335. FLUID-PRESSURE DEVICE. RICHARD LIEBAU, Watervliet, N. Y.

1. The combination with members having a sliding joint therebetween and forming a chambered device capable of movement for compression and extension, of liquid and gaseous

1,146,775. APPARATUS FOR PNEUMATICALLY DELIVERING MATERIAL. GILBERT H. GILBERT, New York, N. Y.

JULY 20.

1,146,781. SUBMARINE ARMOR. HARRY L. BOWDOIN, Bayonne, N. J.

1,146,870. DRILLING-MACHINE. CHARLES H. HAESELER, Philadelphia, Pa.

1. In a drilling machine, the combination of a drilling engine including a cylinder, a hammering piston reciprocable therein, a rotatable tool holder at the front end of the cylinder, a back head for the cylinder, a rotary motor mounted in the back and reduction gearing between the motor and tool holder.

1,147,002. AIR-PUMP. THOMAS S. CAUSEY, Dallas, Tex.

1,147,064. VACUUM BLACKBOARD-ERASER. MILES V. WOLF, Ashland, Ohio.

1,147,148. AIR-CUSHION. CHARLES I. DICKERSON, Duchesne, Utah.

1,147,150. METHOD OF OBTAINING OXIDS OF NITROGEN FROM ATMOSPHERIC AIR. FRANCIS I. DU PONT, Wilmington, Del.

1. The hereinbefore described method of producing oxids of nitrogen from mixtures of oxygen and nitrogen which consists in isolating

successive and independent quantities of the mixed gases and within a space having considerable length relatively to its diameter, subjecting each volume of mixed gases to the influence of an electric arc, drawing out the arc in the lengthwise direction of extension of said volume of mixed gases, proportioning the amount of current in the arc to the diameter of said volume of mixed gases so as to effect a substantially instantaneous heating of the latter to a high temperature and simultaneously therewith converting the heat into mechanical energy.

1,147,242. AUTOMATIC BRAKE-RELEASER. EDWARD O. HENTSCHEL, Cincinnati, and WILLIAM F. C. HARTING, Elmwood Place, Ohio.

1,147,265. PRODUCTION OF OZONE. JOHN ROBERT QUAIN, London, England.

1,147,286. SPRAYER. FRED S. WELCH, Pontiac, Mich.

1,147,370. INTERNAL-EXPLOSION ENGINE. CONRADIN ALFRED BREITUNG, Seattle, Wash.

liquid supply; filling mechanism connected to said tank; and means for supplying gas under pressure to said tank and to a container to be filled, said means comprising hydraulic means for maintaining a constant excess pressure on the liquid entering said container over the gas pressure in said container.

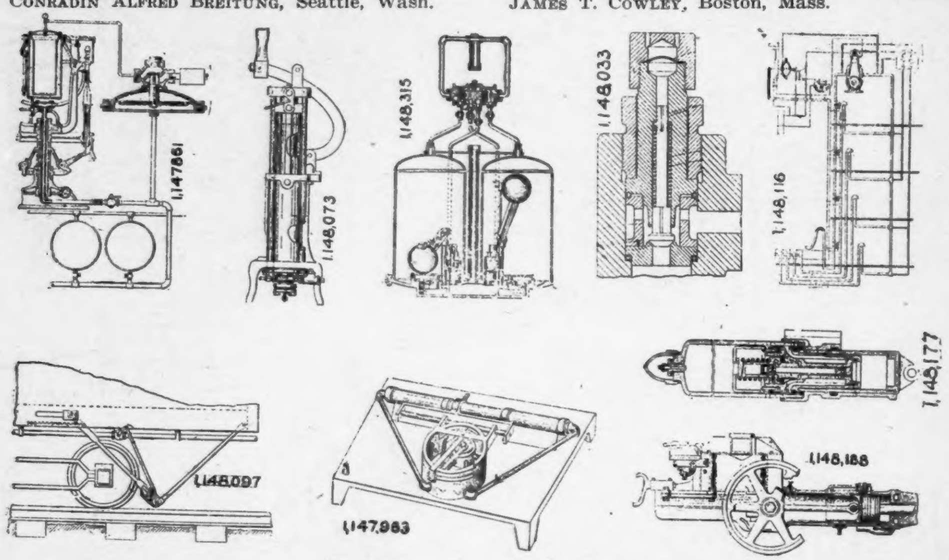
1,147,963. RECIPROCATING FLUID-MOTOR. WALTER J. MEILUK, Hamilton, Ontario, Canada.

1,148,025. AIR-RELEASING APPLIANCE FOR SIGNALS, SWITCHES, AND THE LIKE. CLEBURG WESLEY KILLIAN. Oakland, Cal.

1,148,033. PUMP OR COMPRESSOR. ERNEST WILLIAM HERBERT McMICHAEL, Waltham Cross, England.

1,148,073. AIR-PUMP. PETER JACOB BODE, St. Louis, Mo.

1,148,077-82. PNEUMATIC AMMUNITION ELEVATING AND LOADING DEVICE. JAMES T. COWLEY, Boston, Mass.



PNEUMATIC PATENTS JULY 27.

1. In an engine, in combination, a main or power developing rotor, a preliminary-air-compressing chamber and a rotor therein connected to and rotating with the main rotor, a final-compression cylinder and a piston therein operated from the main rotor, a valve between said cylinder and the preliminary-air-compressing chamber, a valve between said cylinder and the main rotor, and means for operating said valves from the main rotor.

1,147,436. HYDROPNEUMATIC LOCOMOTIVE REVERSING-GEAR. EUGENE L. RAGONNET, Langhorne, Pa.

1,147,438. VACUUM - OPERATED GLASS-LADLE. SOLON O. RICHARDSON, JR., Toledo, Ohio.

1,147,560. MASSAGE APPARATUS. FRANK SHURTLEFF and WILFRED SHURTLEFF, Moline, Ill.

1,147,646. AIR-COMPRESSOR. WILLIAM F. ROBBINS, Scranton, Pa.

JULY 27.

1,147,820. ELECTROPNEUMATIC SWITCH. WILLIAM M. SCOTT, Philadelphia, Pa.

1,147,861. PACKAGING LIQUIDS. FRANK HENNEBOHLE, Chicago, and GERHARDT J. PATITZ, Oak Park, Ill.

1. In a liquid filling machine, the combination of a filling tank connected with a source of

1,148,097. EMERGENCY AIR-BRAKE APPLIANCE. FORTES M. KLECKNER, Drumright, Okla.

1,148,116. PNEUMATIC - DESPATCH - TUBE APPARATUS. JOHN T. NEEDHAM, Bayonne, N. J.

1,148,177. VEHICLE AIR-SPRING. RICHARD LIEBAU, Swissvale, Pa.

1,148,188. PRESSURE DEVELOPING AND DRIVEN TOOL. ALEXANDER PALMROS, Syracuse, N. Y.

1. A reciprocating tool comprising fluid pressure developing and driven members, a common cylinder for said members, a fluid pressure storage chamber situated to receive fluid under pressure from said pressure developing piston during its forward stroke, a valve controlled intake port and a discharge port, said pressure developing member having a rearward extension for closing said discharge port during the greater part of its stroke, said ports establishing communication between the cylinder of said members and said storage chamber.

1,148,310. PNEUMATIC TOOL. GEORGE H. GILMAN, Claremont, N. H.

1,148,315. HYDROPNEUMATIC PUMP. BENJAMIN S. H. HARRIS, Greenville, S. C.

1,148,371. PNEUMATIC FEEDING MECHANISM FOR BRANDING OR PRINTING MACHINES. ORIN C. FENLASON, Hoquiam, Wash.

1,148,376. PNEUMATIC INSOLE. SAMUEL S. GAY, Sedro Woolley, Wash.

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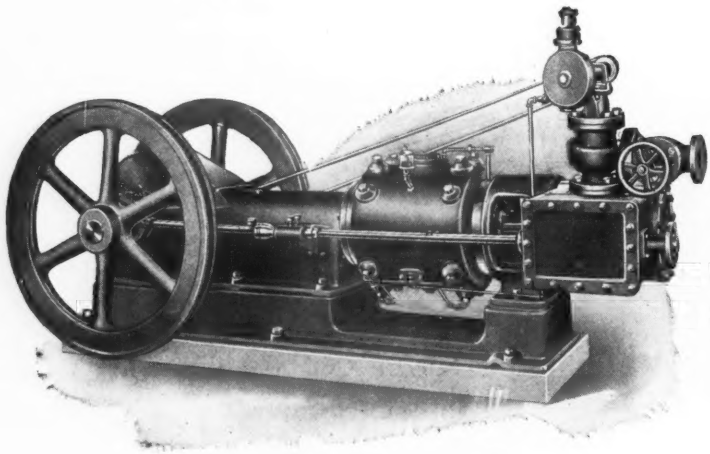

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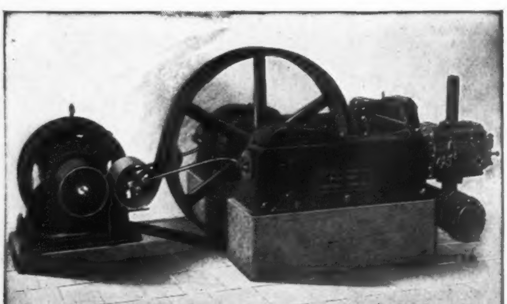

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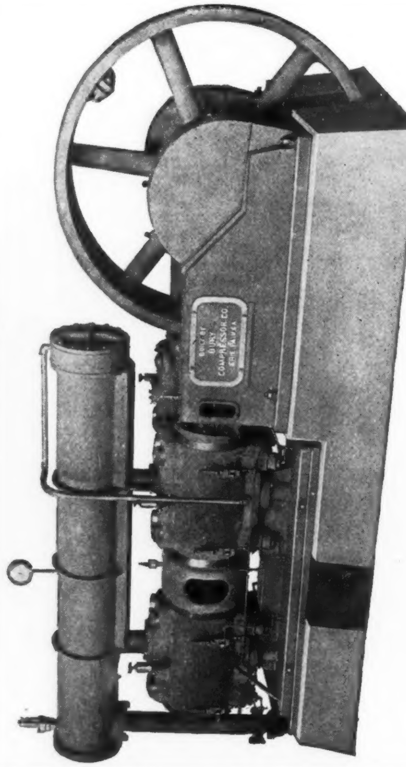

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